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CONTENTS

	Page
Scientific and Industrial Research in Great Britain	709
Recent Works on Cytology. By Prof. I. Manton	712
Marine Bacteriology. By Dr. H. W. Harvey, F.R.S.	713
The Birds of Kutch. By N. B. Kinnear	714
Elementary Electricity and Magnetism. By G. R. Noakes	714
Ionic Permeability of Skeletal Muscle Fibres. By Prof. Edward J. Conway	715
British Prehistoric Archæology: Recent Aims, Methods and Results. By C. F. C. Hawkes	717
Physiology of Fertilization. By the Right Hon. Lord Rothschild	720
Obituaries:	
Prof. E. G. Coker, F.R.S. By Prof. G. T. R. Hill	722
Prof. T. H. Bryce, F.R.S. By Dr. E. Ashworth Underwood	723
Mr. E. G. Boulenger. By Dr. Geoffrey M. Vevers	724
Mr. C. A. Watts	724
News and Views	725
Letters to the Editors:	
Responses of Seedlings to Animal Embryonal Extracts.—Laszlo J. Havas	728
Number of Tentacles in *Hydra vulgaris* as a Genetic Character.—T. T. Liu and Joseph T. Chang	728
Transmission of the Carbon Dioxide Susceptibility of *Drosophila* by Grafting.—Prof. Ph. L'Heritier and F. Hugon de Scoeux	729
Digestion of Animals by Lamellibranchs.—Prof. C. M. Yonge, F.R.S.	729
Musa Fehi, the Indigenous Banana of Fiji.—Dr. K. S. Dodds	729
Changes in the Contents of Acetylcholine in Nervous Tissue under the Influence of Constant Currents.—Eug. B. Babsky	730
Porphyrin Formation by Yeast.—Dr. J. E. Kench and Dr. J. F. Wilkinson	730
Inhibitory Effect of Tetranitromethane on the Diphtheria Toxin–Antitoxin Precipitin Reaction.—Dr. Lars Ehrenberg, Miss Inga Fischer and Dr. Nils Löfgren	730
Synergic Effect of Ascorbic Acid and Riboflavin on Penicillin *in vitro*.—Dr. Mahmoud A. Jalili	731
Changes in the Electrical Charge of Yeast Cells Treated with Sodium Fluoride.—Dr. Mignon Malm	731
Crack-Heal Mechanism of the Growth of Invisible Films on Metals.—Dr. U. R. Evans	732
Combustion of Carbon.—J. R. Arthur	732
Resonance Energy of the Tetrachlorethylene Molecule.—Dr. Jules Duchesne	733
Saturated Adsorbed Films and the Structure of Deeply Supercooled Water.—Dr. D. H. Bangham	733
Elimination of Divergencies in Quantum Electrodynamics and in Meson Theory.—Prof. Torsten Gustafson	734
Preparation of Synthetic Quartz.—R. M. Barrer	734
Scattering of Polarized Light by a Colloidal Graphite Solution.—Prof. John J. Dowling	734
Magnetic Permeability of Nickel in the Region of Centimetre Waves.—I. Simon	735
Solubility and Heat of Solution of Caprylic Acid in Water.—Prof. F. H. Constable and S. Tegul	735
Effect of Heat on Wool, Cotton and Nylon.—A. O. Lloyd	735
Use of Polymers to Immunize Wool Against Acid Dyes.—M. Lipson and Prof. J. B. Speakman	736
Luminosity Curve of Trichromats.—Dr. Hl. de Vries	736
Planck's Radiation Formula.—David G. Kendall; Prof. Herbert Dingle	737
Stefan's Radiation Law.—John Satterly	737
Biology in Italy.—Alberto Stefanelli	737
Radiation and Living Cells	738
Chemistry of the Feulgen and Dische Nucleal Reactions. By Dr. M. Stacey, R. E. Deriaz, Dr. Ethel G. Teece and Dr. L. F. Wiggins	740
Ant Gynandromorphs and Other Mosaics. By Derek Wragge Morley	741
National Central Library	742
Rheology in the Food Industry	742
Plant Viruses	743

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SCIENTIFIC AND INDUSTRIAL RESEARCH IN GREAT BRITAIN

THE attention which has been directed to the Department of Scientific and Industrial Research by a number of addresses by Sir Edward Appleton, such as those to the National Union of Manufacturers, to the Northern Industrial Group, and to the Manchester Literary and Philosophical Society, as well as by the Federation of British Industries Conference on "Industry and Research", has been strengthened by the publication of the details of the estimates of the expenditure of the Department for 1945–46 and for 1946–47. The gross total of £1,817,217 for the former year, or £1,405,271 net, is to be increased to £2,390,934 net for the latter year. Grants to the research associations, now numbering thirty, will be increased from £423,400 in 1945–46 to £860,600 in 1946–47, the latter sum including £200,000 as capital grants. This increase is due both to the expansion of existing research associations and the formation of new ones. Excluding the Intelligence Division and the British Commonwealth Scientific Office, the estimated cost of general headquarters administration amounts to only 2·27 per cent of the gross total.

Little information has as yet been supplied on the work of the Department of Scientific and Industrial Research during the War, although Sir Edward Appleton's addresses and speeches made by Mr. Herbert Morrison, as Lord President of the Council, have given pointers, as has a recent report from the director of the Wool Industries Research Association. There are incidental references in Sir Frank Heath and Mr. A. L. Hetherington's recent book "Industrial Research and Development in the United Kingdom", and it is understood that a departmental report is in preparation covering the six years since the first interruption of the series of reports issued annually from 1916. In the meantime, notes recently issued by the Department indicate that much of the work of the research associations during the War was on similar lines to that disclosed in the last annual report of the Wool Industries Research Association, namely, the cheapening and speeding up of manufacturing processes, finding alternatives to scarce materials, and developing methods of extending the life of materials. A spectacular result was the preparation of waterproof cotton cloths by the British Cotton Industry Research Association. These cloths are so constructed as to possess a high degree of resistance to water and become water-tight when wet. Hose-pipes, canvas tanks, tents and covers, as well as clothing have been made of this material, and the development has considerable possibilities for export.

Other activities of the Department include the investigation by the Coal Survey Laboratory of methods of storing coal and particularly for putting out fires in dumps, a problem which has assumed great importance since 1942 in view of the necessity for holding much larger stocks. Methods were recommended for putting out fires in dumps, and rules laid down for stacking coal to prevent heating and spontaneous combustion. Again, work in the

Chemical Research Laboratory has led to the production from home raw materials of a cheap and effective foaming agent for fighting petrol fires which has rendered possible the use of a high-efficiency foam from the R.A.F. aircraft crash tenders. During the War the whole of the production was used for this purpose.

The Chemical Research Laboratory was also successful in synthesizing a new drug 'Phenanthridinium 1553', for the control of nagana disease in cattle, due to trypanosomes, especially *T. congolense* in South Africa, and manufacture of the drug by two firms is now proceeding. The Water Pollution Research Laboratory has devised methods of disposal of liquor from shell-filling factories which renders unnecessary expensive schemes for laying pipe-lines. The Geological Survey discovered, and assisted in the development for the manufacture of optical glass of, a large deposit of sand at Lochaline on the Sound of Mull; the purity of this sand exceeds that of the best of the Continental quartz sand imported before 1940 from Belgium, Holland and France, to the value of more than £200,000 annually. A dangerous scarcity was thus avoided and there are adequate resources for the future. Again, in collaboration with the Agricultural Research Council, agricultural colleges and the Duke of Northumberland's Fund, the Chemical Research Laboratory has developed a very successful sheep dip incorporating D.D.T., which should greatly reduce the losses of tens of thousands of sheep every year from blowflies.

These references to the work of the Department during the War stimulate interest in the reference made to the newly established Intelligence Division, which Sir Edward Appleton described in his address to the National Union of Manufacturers. Moreover, as he pointed out to the Northern Industrial Group, certain sections of his Department are particularly well equipped to assist special areas or industries: the Fuel Research Station, the Geological Survey and the Water Pollution Research Laboratory, for example, are already carrying out work of vital importance to the development or reconstruction of the north-east coast of England, and the formation of a research council for that area, as urged by Sir Edward, should foster the co-operation between industry, research institutions and universities, so essential for the utilization of existing, as well as for the discovery of new, knowledge.

It was no doubt with this in mind that Sir Edward Appleton spoke so strongly at the Federation of British Industries Conference. He believes that secrecy is unjustified in connexion with practically all the purely scientific work which lies at the back of industrial research, and that if we could get at the facts we should find that industrial firms working in the same field and maintaining a close silence about their research are often merely keeping secret matters which are actually known to each of them. The elimination of such unjustifiable secrecy, both in Government and industry, is an essential step in co-operation and the effective organisation of our research effort.

This view is supported by the Lord President of the Council, who, in his speech at the annual luncheon of the Parliamentary and Scientific Committee, expressed the opinion that in the past there has been too much repression of scientific freedom to mix, and to publish, both by Government and by industry. So far as the Government is concerned, Mr. Morrison said he hopes to see wide freedom in this respect, with the exception of certain work which by general consent must remain on the secret list. Mr. Morrison's responsibilities as Lord President of the Council go far beyond the Department of Scientific and Industrial Research, but much of what he was able to say on that occasion regarding developments under the Agricultural Research Council and the Medical Research Council was reflected in the discussions at the Federation of British Industries Conference, where Mr. Morrison himself again referred to the importance of the pooling of knowledge and of collaboration in research at the present time, mentioning, incidentally, the official Advisory Service on Production Efficiency.

Other speakers at the latter Conference, such as Sir Raymond Streat, recognized that while secrecy, on competitive and commercial grounds, is not wholly unreasonable, the habit is often carried to absurd lengths, and he insisted on the need for applying in industry some of the principles lying behind operational research during the War. Dr. P. Dunsheath emphasized the importance of freedom of publication where fundamental or work of a general nature is concerned, while Mr. A. J. Philpot, director of the British Scientific Instrument Research Association, as well as Sir Robert Robinson, cited examples of the value of team-work and of the possibility of so organising it as to leave the individual members of the team free to develop their own ideas. That is, of course, part of the problem of securing the environment which is most favourable to creative work, and Dr. Dunsheath's observations on this theme were warmly welcomed by Sir John Anderson, who commended the study of the organised employment of scientific workers in industry as a problem which might fruitfully occupy the attention of the Federation of British Industries.

A major point in Sir John Anderson's speech, however, concerned the whole conditions in which the Department of Scientific and Industrial Research or any research organisation has at present to work. We have created a community in which, outside the ranks of specialists, far too few people have any scientific training at all. The administrative branches of the Civil Service, he asserted, would be better equipped for their tasks if they contained a reasonable proportion of men and women with scientific training, and this is probably true of administrators in commerce and industry as well. On the other hand, the scientific worker himself is too often launched on the world with an inadequate general grounding. Correction of these two defects springing from a single cause would give us a better balanced community, greater efficiency and better understanding all round, and diminish the controversy regarding the relation of the specialist to the administrator.

This criticism of the educational system of Britain emphasizes the importance of the Percy Report; but the universities and technical colleges do not carry

the sole responsibility for remedying the position. The Department of Scientific and Industrial Research itself has some responsibility through its system of grants to promising research workers, as well as of maintenance grants to students. While the Department continues to bear such responsibilities, whether the primary purpose is the training of the research worker or the encouragement of the prosecution at the universities of researches of special timeliness and promise which otherwise would not be undertaken or would not be pursued with the rapidity desirable, such awards might well be made on a more generous scale; further, they might be given without the irritating inquiry into personal means and individual circumstances that tends to deter application from many whom it might be to the nation's best advantage to encourage.

A most encouraging feature of the Federation of British Industries Conference was the disposition on all sides to give generous encouragement to the research worker, whether in industry or the universities. Sir John Anderson and Sir Raymond Streat touched on the value of setting men aside to keep track of new developments either in a firm's own industry or in wider fields that might affect it. Sir Robert Robinson summarized the policy of industry towards the universities, as supporting the universities, giving them their head, and keeping in touch with them; but he ended by insisting that the first desideratum in industrial research to-day is an extension of scientific and technical education so as to render possible the massing of the battalions of research. Indeed, this summons for the extension and improvement of scientific and technical training, and particularly the latter, was one of the most significant features of the Conference. As Sir Henry Tizard said, although the quality of scientific education in Britain will bear comparison with that of any other nation, we are behind in the quality of our technical education, particularly in the branches of higher technology.

What is already clear from the proceedings of this Conference is that the expansion of the Department of Scientific and Industrial Research is being matched by a considerable expansion of research effort in industry itself. A recent survey by the Federation of British Industries established that there are at present some 9,000 graduate scientific workers engaged on research and development in British industry. So far as has been ascertained, the total annual expenditure on such research and development is of the order of twenty million pounds, and those industries which have contributed to the survey propose in the next two years to increase their scientific staff by twenty-five per cent, and their laboratory space by more than two million square feet.

These are facts against which to set the present total annual expenditure of the research associations of Britain of upwards of one million, and the plans in preparation to increase this to more than two million pounds within the next five years. They accentuate too the importance of the problem of scientific man-power now under investigation by the Barlow Committee, and they indicate the value of fully exploring the newer ideas in the organisation of research, such as the nuclear group described by Dr. Dunsheath, the lessons of operational research or of the team-work which went to the development of penicillin or radar, and of close attention to organisation; not only to avoid overlapping and duplication of effort, but also to secure the environmental conditions which will prove most stimulating to the creative and inventive powers of the investigators.

Both the strategy and tactics of research are being re-examined, and when the Department of Scientific and Industrial Research lifts the veil on its activities during the past six or seven years, its whole organisation and structure as well as its achievements will be reviewed in the light of that Conference and of the war-time experience in team-work and operational research inside and outside the Department. No reasonable doubts exist as to the value of the Department as the primary instrument of the State for fostering research in branches of science other than medicine and agriculture, and Sir Frank Heath and Mr. A. L. Hetherington in their recent survey of industrial research and development in the United Kingdom make plain the full extent of the contribution to industrial development and national welfare already made by the Department, and indicate the way in which the Department is preparing not merely to increase the scale of its effort but also to face the newer problems arising. Moreover, the proposals for the establishment of similar organisations in South Africa and in India, following on the earlier examples of Canada, Australia and New Zealand, are in themselves a striking tribute to the proved value of this British innovation.

What is required, however, and what the resumption of the publication of the annual reports of the Department as a whole and of its individual boards will facilitate, is a closer appraisal of the place of the Department in the nation's research effort, the relation of the work of its laboratories and research stations to the general organisation of research in industry and at the universities and technical colleges, particularly in the light of what the War has taught us about team-work. The fostering of research in the technical colleges as contemplated in the Percy Report may in itself have some bearing on research carried out by the Department, and the time appears to be ripe for some more fundamental assessment of the whole system of industrial research associations and their functions.

Much background to that appraisal is provided by Sir Frank Heath and Mr. Hetherington and by the Federation of British Industries Conference, and debates in recent years on scientific and industrial research have helped to clarify some of the issues. The tactical questions of the conditions most favourable to fertile research are receiving no small measure of attention, and there is evidence of general agreement on most of the answers. Questions, however, may still be asked as to how far the machinery of Government for handling scientific questions could be improved, and the use that could be made of the Department of Scientific and Industrial Research, not merely for the prosecution of actual research, but

also for fostering higher standards and more fruitful conditions of research both in industry and in the universities. The restoration of full freedom of publication and the encouragement of exchange of staff between industry and the universities and the Government service, apart altogether from collaboration in actual research, cannot but enhance the potentialities of the Department as an instrument for this latter purpose if the Government is so minded. Meanwhile, Sir Edward Appleton's addresses and the speeches of the Lord President of the Council afford some ground for the belief that when the review of the Department's war-time activities appears, it will be as notable for its constructive proposals for the future as for the past achievements recorded.

RECENT WORKS ON CYTOLOGY

Cytological Technique

The Principles and Practice of Methods used to determine the Structure of the Metazoan Cell. By Dr. John R. Baker. (Methuen's Monographs on Biological Subjects.) Second edition, re-written and enlarged. Pp. vii+212. (London: Methuen and Co., Ltd., 1945.) 6*s*. net.

Chromosome Atlas of Cultivated Plants

By Dr. C. D. Darlington and Dr. E. K. Janaki Ammal. Pp. 398. (London: George Allen and Unwin, Ltd., 1945.) 12*s*. 6*d*. net.

Animal Cytology and Evolution

By M. J. D. White. Pp. viii+375. (Cambridge: At the University Press, 1945.) 36*s*. net.

THREE books on cytological subjects published so soon after the close of hostilities is perhaps a wholesome sign of activity in an expanding field of biological knowledge. The three are of widely different types. Baker's little volume on technique is a welcome second edition, emended to include much of the author's own most recent work, notably that on the Golgi apparatus. Like its predecessor, it fills a position not easily catered for by any other book. It is an account of cytological methods, not in the sense of supplying a beginner with instructions and formulæ, but as an analysis as full as present knowledge permits of the basic physical and chemical processes underlying the cytological methods in current use. For any worker wishing to understand the reasons for the things he does or requiring to modify or devise technical methods for particular purposes the information supplied is invaluable, and the small size and low price of the book should bring it easily into every cytological laboratory.

The "Chromosome Atlas of Cultivated Plants" is a list of chromosome numbers, not as one might perhaps expect, of cultivated plants in particular, but of a large number, though by no means all, of the cytologically known species of Angiosperms and Gymnosperms, whether cultivated or wild, together with the names of a number of commercially important species for which no cytology exists; the latter no doubt inserted to stimulate investigation. The labour involved in such a compilation is enormous, even with the excellent previous lists of Prof. Tischler and others to go upon, and the distinguished Indian compiler may be forgiven the rather numerous inaccuracies, many of which will doubtless disappear in later editions. More fundamental comments concern method.

There can scarcely fail to be differences of opinion on the merits of arranging the genera within families in order of ascending chromosome numbers. A bird's-eye view of some of the statistical aspects of chromosome distribution within a group is perhaps facilitated by such a system; but phyletic it cannot be. Whether it will mislead the inexperienced and infuriate the taxonomist remains to be seen; but there is clearly a risk that it will do both in a way which other arbitrary systems, for example, the alphabetical, do not.

Another point that the reader will find not always helpful is the decision to give only one author reference—the latest known to the compilers—to each chromosome count. This may force a would-be inquirer to search for an obscure journal when a common one would do, and gives no clue as to the extent of the available literature. Economy of space is no doubt effected by this. But, one may ask, for whom is this book compiled? If for the horticulturist, might it not be better to make it authoritative and complete for the limited field of cultivated plants which purport to be its main concern; or if for a basic work of reference, of value to pure science, does space (to this extent) matter?

For any class of readers it may be suggested that an introductory chapter summarizing the factual content, without interpretation, would be of value. A reader seeking chromosome numbers does not need to be introduced to the whole field of cytogenetics in a few condensed pages, nor can this properly be done, without grave loss of sense of proportion, in a context of chromosome numbers alone. It would, however, help many people to be told where among the 300-odd pages of lists may be found outstanding examples of, for example, high numbers, low numbers, variable numbers within a species, large chromosomes, small chromosomes, apogamy, etc. At present, though one may know that the highest chromosome number yet recorded in plants is here, it will take a long and troublesome search to find it.

Another detail that may seriously be recommended for reconsideration if this book is to be re-issued as a scientific work of reference is the inclusion of authorities for the specific names. The English or American popular names are admittedly of importance to the horticulturist; but the correct citation of the Latin names is no less important to the man of science. Anyone with taxonomic experience is painfully familiar with the endless confusion that the loose employment of synonyms can cause. The only safeguard is to append the initials, or other recognized abbreviation, of the describer of the species, and these few extra letters are rightly regarded by taxonomists as an integral part of the name; with them a doubt can at once be resolved by reference to the "Index Kewensis" which will give the source of the description; without them it may be impossible to determine what plant is intended.

White's book on "Animal Cytology and Evolution" is a praiseworthy attempt to summarize the known cytological facts of evolutionary importance in the animal kingdom. The closeness of citation precludes easy reading, but as a source of reference the book has much to interest botanists and zoologists alike. Chapters 1–5 give an introductory account of general cytology to the extent needed to understand the methods of cytogenetic analysis, but the real purpose

of the book is contained in Chapters 6–14. These summarize and discuss the present state of knowledge on a few principal themes which may be summarily listed as: (1) evolution in the genus *Drosophila*; (2) distribution and characteristics of chromosome numbers in the animal kingdom; and (3) range of types of life-history, the latter in bewildering variety.

The general effect of such a survey is very far indeed from revealing the mechanism of evolution in its entirety, as the author would no doubt agree. In animals, as in plants, certain types of evolutionary change and certain types of organisms lend themselves to study far more readily than others, and the resulting picture is of necessity both fragmentary and distorted. The fundamental causes of evolution on the grand scale, as it has occurred through geological time and in the fashioning of the great groups of animals and plants, cannot yet be described or explained. Cytogenetics is nevertheless a powerful tool, the most powerful to be forged since Darwin's day, for the analysis of some evolutionary processes that have actually occurred in Nature. We are only at the beginning of exploration of the organic world by its means, and it is very desirable that bulletins of progress in particular fields should be issued from time to time for the guidance of fellow-workers. White's book is a contribution of this kind, and if it were to do no more than provide the student of evolution in plants or animals with a summary and background to the recent literature on *Drosophila*, it will have served a very useful purpose.

I. Manton

MARINE BACTERIOLOGY

Marine Microbiology

A Monograph on Hydrobacteriology. By Prof. Claude E. ZoBell. (A New Series of Plant Science Books, Vol. 17.) Pp. xvi + 240. (Waltham, Mass.: Chronica Botanica Co.; London: Wm. Dawson and Sons, Ltd., 1946.) 5 dollars.

During the past fourteen years, two series of investigations have been made concerning the part bacteria play in the cycle of life which takes place in the sea, one at the Scripps Institution by Dr. C. E. ZoBell and co-workers, the other at Woods Hole Oceanographic Institute by Dr. S. Waksman and others. These have provided much information on the chemical activities, characteristics, distribution, and have indeed established the salient features of the ecology of marine bacteria. The results of these and other investigations have appeared in numerous journals and reports, but have never hitherto been collected into a cohesive account.

More than six hundred references appear in the bibliography of "Marine Microbiology", which is devoted to the bacteriology of the sea and its bottom deposits, of its fauna and flora, of the air over the sea, and comparison with conditions in fresh waters. Except for a chapter on marine yeasts and other fungi, it does not deal with the very numerous other Protozoa and unicellular plants as its title would suggest.

After discussing the marine environment, methods of collection and of counting the bacteria, the factors influencing their distribution are considered. Near shore their numbers are greatest, and many terriginous species are found in suspension in the water, while farther seaward the numbers usually fall to 50 or less per c.c., comprising numerous species. Most of these will not live in freshwater media, occur attached to particulate matter or in clumps, are motile and can grow in filtered sea water, which is an extremely dilute nutrient medium containing only some 5 mgm. of organic matter per litre, only half of which is readily available. These truly marine and planktonic bacteria play a major part in the breakdown of several thousand million tons of organic matter in the oceans every year; they are mostly proteolytic, and species have been isolated which can utilize such diverse compounds as chitin, cellulose, fats, lignin, starch and hydrocarbons.

These planktonic forms readily attach themselves to solid surfaces, when they grow more rapidly, and are found in greatest numbers where there is most particulate matter in suspension. The effect of bottling sea water containing a few hundred bacteria per c.c. is to raise the number to several million per c.c. within a few days. If a glass slide is hung in the sea, it is rapidly coated with bacteria. The low bacterial population in the sea is attributed to lack of solid surfaces on which organic matter in solution can be adsorbed to provide a better food supply, to the antagonistic effect of other micro-organisms either feeding on them or excreting heat-labile toxic products, to the possible presence of bacteriophage (for which there is some evidence), and to their being carried down when attached to sinking particles of detritus.

Two chapters are devoted to bacteria in bottom deposits, several million per gram occurring in the superficial layers of a mud bottom, the population decreasing with depth in the mud along with a similar decrease with depth in the organic matter present. Fewer bacteria occur in deposits of sand or silt than in mud. Aerobes are more abundant than anaerobes. The changes they are capable of bringing about are many and include the decomposition of very varied organic substances, the reduction of sulphate to sulphide, and of nitrate to nitrite and nitrogen. By production of ammonia they can cause the precipitation of chalk, and there is evidence that they play some part in the formation of iron and manganese nodules. Further chapters are devoted to sulphur bacteria, to conditions in the Black Sea, limans and salt lakes.

Concerning the relation of bacteria to plants and animals, there is collected much of interest to the marine biologist. Their integuments appear to be veritable bacterial gardens. Several species are recorded as pathogenic to plants, others to animals; the intestinal flora of marine animals elaborate a formidable equipment of enzymes which may well aid the digestion of pectins, hemicelluloses and chitin not readily attacked by the consumers' own digestive fluids. It is likely that the ship-worm, which digests most of the cellulose passing through it, is at least helped by commensals, since the gut contains large numbers of cellulose- and lignin-splitting bacteria. There are interesting records of bacteria serving as food for marine filter-feeding animals.

The regeneration of phosphate and salts containing nitrogen by bacterial breakdown of dead vegetable and animal matter is treated in two chapters, these being essential steps in the cycle which permits continuous life in the sea.

The bacteriology of shellfish and human pathogens, the decay of nets and spoliage of marine food products are also discussed.

The main characteristics of marine bacteria appear to be their capacity to maintain life in a natural medium with dissolved organic matter at extreme dilution. The majority are motile, chromogenic, and rather small, averaging 2–3 μ long and 0·4–0·6 μ in diameter, *Pseudomonas* and *Vibrio* species preponderating. Spore formers and Gram-positive cells are rare. They grow best in culture at 18–20° C. and are more heat sensitive than fresh-water bacteria, ten minutes at 30°–40° C. killing the majority. Relatively few grow in freshwater media.

Dr. ZoBell has succeeded in collating numerous investigations and presenting the essential information in a most readable, well-planned and inclusive treatise. In the words of Dr. Waksman, who has written a foreword to the volume, he "has rendered a distinct service to the bacteriologist, to the oceanographer and to all those who are interested in the cycle of life in natural water basins".

Well written, suggestive of many intriguing problems awaiting investigation, this book will surely give further impetus to the study, not only of bacteria, but also of all the small creatures in the sea.

H. W. HARVEY

THE BIRDS OF KUTCH

The Birds of Kutch
By Sálim Ali. (Published for the Government of Kutch.) Pp. xviii + 175 + 35 plates. (London: Oxford University Press, 1945.) 35*s.* net.

THE native State of Kutch in the northern corner of the west coast of India is only some 7,600 square miles in extent, but nevertheless is of more than ordinary ornithological interest. This is due to the geographical position between Sind, with a strong palæarctic element in the avifauna, and the purely oriental peninsula of India. Some palæarctic species —such as the cream-coloured courser (*Cursorius cursorius*) and the desert lark (*Alæmon desertorum*)— extend into Kutch, but an examination of the races of the resident birds shows that they tend to be nearer those found in Kathiawar than in Sind. The difference is, however, slight since Kutch is really a transition zone between the two areas. Three generations of rulers of Kutch have taken a great interest in natural history, more especially birds. It was owing to the encouragement of the present Maharao's grandfather that Palin wrote the "Birds of Kutch", which was published in 1878, with a second edition by Captain Lester in 1898. Now we have an entirely new work on Kutch birds published under the authority of the State Government. The author, Mr. Sálim Ali, is a recognized authority on Indian birds and a good field naturalist. Through the interest of the Maharao he was enabled to pay two visits in 1943 and 1944 to make a survey of the avifauna which had never been done before in any detail.

On the northern frontier of Kutch is the well-known Rann, a large expanse of sand and dried mud, heavily impregnated with salt. After a good rainy season the greater part of the area is flooded, but it gradually dries as the season advances. Here is the last remaining haunt of the Indian wild ass and here too the only breeding-place of the flamingo in India. While visiting the flamingo colony in March 1944, Mr. Ali made a very interesting discovery. Within half a mile of the nesting flamingoes he found a large number of avocetts breeding, which he estimated at five hundred pairs. The colony was on an island, and eggs were laid on the hard sun-baked mud. Avocetts have never previously been recorded breeding in India, and the nearest colony is said to be in north Baluchistan.

Mr. Ali considers that Kutch is an ideal place to watch bird migration in the autumn. Many birds pass through the State on their way to winter quarters in Africa, others to continue their passage down the Indian coast, while some remain the winter in the State. Owing to the bare nature of the country, birds can be easily seen and in the early autumn the pools in the Rann are a resting-place for large numbers of migrating geese, ducks and waders. The return journey appears to be performed by another route; at least it is not very marked in Kutch.

There are twenty coloured plates which, with the paragraphs on field identifications, should enable most birds to be recognized. The notes on habits are admirable, based on the author's wide experience in many parts of India, and in the small space at his disposal he has brought out the salient facts.

This is a useful contribution to the ornithology of India and we hope that in the future Mr. Ali will give us a volume on one of the adjoining areas.

N. B. KINNEAR

ELEMENTARY ELECTRICITY AND MAGNETISM

Electricity and Magnetism for Students
By S. R. Humby. Pp. 336. (London: John Murray, 1945.) 6*s.* 6*d.*

IN this, the second edition, Mr. Humby has added an account of talking films and television, and also a chapter on the principles of radio. The material of the 1939 edition appears unaltered; indeed, there were no errors or significant omissions to rectify, and the references to modern work still appear fresh and up to date.

Students at the higher school certificate stage, for whom the book is intended, need something more than a mere presentation of facts and principles; it is desirable to impress upon them the unity of the subject as it stands to-day. The author has realized this, and (following the excellent example of Pohl) has related the work on electrostatics in the early chapters to the discussion of the nature of conduction by solids, liquids and gases, which occupies three consecutive chapters towards the end of the book. But some readers may criticize the resulting sequence of topics. Ohm's law is first enunciated, and resistance defined, in Chapter 10; many applications of the law, from the de Sauty bridge in Chapter 2 to the treatment of alternating current in Chapter 9, precede its revelation. This criticism is foreseen, and to some extent disposed of, in the preface, where it is stated that each chapter is complete in itself, to permit free choice of order.

The book covers all the essential work for higher school certificate and university scholarship examinations, and treats the difficulties of electrostatic theory exceptionally well. The additional chapter provides as much of the elementary theory of radio communication as students at this stage will require, and is concisely presented, without too much technical detail; it should increase the book's usefulness, and serve as a helpful guide to later reading.

G. R. NOAKES

IONIC PERMEABILITY OF SKELETAL MUSCLE FIBRES

By Prof. EDWARD J. CONWAY
University College, Dublin

A CERTAIN kind of ionic permeability would appear to be of advantage to the cells of higher organisms[1]. As there was strong evidence that it exists in skeletal muscle[2,3], liver cells, and those of the proximal convoluted tubules[4], it was termed the 'standard' permeability for ions; and it was believed to apply to at least the greater fraction of the soft tissues of the higher organisms, and possibly to all or almost all such cells in their formative periods.

With such permeability, cations and anions up to certain size limits diffuse passively through the membrane. Thus, while potassium ions pass freely, sodium ions are excluded or virtually so, and while chloride ions enter the cell, the phosphate esters are retained.

Here it may be said that if we consider the sodium ion to enter at any rate, however small, but significant compared with the life of the cell, then two regulatory mechanisms may be described: (*a*) the 'standard' permeability, described above; (*b*) a very slow active extrusion of sodium ions.

Complete exclusion of the second possibility has not been my intention, and a possible mechanism—long entertained here—is suggested below. At the same time, it is necessary to point out that active extrusion of sodium ions from skeletal muscle and gland tissue (other than some very special cells), that is, for the major part of the soft tissues of animals, is a quite unproved hypothesis; also, that the reduction of the rate of entrance of sodium ions until it is negligibly small would appear ideally the most advantageous, since it saves free energy. How far a cell, not specially engaged in the active passage of sodium chloride, has achieved this may be taken as a measure of how far it has been thus possible to save energy. (Michaelis[5,6] has studied collodion membranes permeable to potassium ions but almost impermeable to sodium and lithium ions.)

As will be shown[4], in the nephron of the frog, there occurs a striking example of two tissues—one the proximal tubule and the other the distal—in the first of which the 'standard' permeability is manifest, and in the second a comparatively rapid functional extrusion of sodium chloride. The cells of the latter tissue behave quite differently from the former and from skeletal muscle with respect to cyanide and the osmotic control of the external sodium concentration.

The chief purpose of the present article is to indicate, mainly from energy considerations, that the rate of the normal and hypothetical entrance of sodium into such a tissue as the sartorius muscle of the frog can only be a very small fraction of the rate of entrance of potassium, the 'standard' permeability being a far more significant control for at least rapid cellular adjustments than a hypothetical extrusion of sodium ions.

Criticisms of my views have recently appeared in the comprehensive Croonian Lecture before the Royal Society by Krogh[7] and in the valuable recent edition of Höber's "Physical Chemistry of Cells and Tissues"[8] (in which the literature is reviewed up to about 1942).

Krogh refers very generously to the significance of the experiments on isolated sartorii with extensive accumulation of potassium[3] and its theoretical interpretation; but limits such interpretation to the condition of high external concentration of potassium ions, on the grounds that the cells were not normal, having lost their excitability; though it may be said that the non-entrance of sodium during twenty-four hours would be in general regarded as a certain sign that the tissue was living.

Krogh appears to accept the free passive entrance of potassium and chloride ions into normal muscle tissue, but considers the apparent impermeability to sodium as due to an active extrusion, sodium ions entering the fibres as fast, if not indeed faster, than potassium ions. The following may then be considered: *the minimal energy required for extrusion of sodium ions from the normal frog's sartorius, if sodium entered as fast as potassium.*

It has been previously shown[9] that on increasing the concentration of potassium chloride outside the isolated sartorius muscle, it entered the fibres at a rate such that half the equilibrium value was reached in about 40 min. It may be advanced that the tissue was not 'normal' owing to the high external concentration of potassium ions. We have therefore repeated such experiments in a somewhat different way. After immersion in Ringer solution (containing 110 m.eq. sodium chloride, 2·5 m.eq. potassium chloride per litre) for 30 min., the muscles were transferred to a similar solution containing 102·5 m.eq. sodium chloride per litre and 10 m.eq. potassium chloride per litre, companion tissues being maintained throughout in the original solution. Oxygen-bubbling was used for stirring. Taking the mean weight as 100 after the first 30 min., the mean differences in weights of the two sets of muscle are plotted in Fig. 1 (*B*). For this curve six different sets of experiments with a mean of six sartorii in each were averaged to reduce the variability from other causes, the mean change in weight being only upwards of 3 per cent. Curve *A* in Fig. 1 shows the data for a similar group of muscles and solutions, but the potassium chloride content maintained at 2·5 m.eq. per litre throughout. It is clear from Fig. 1 that potassium chloride enters the fibres osmotically active to sodium chloride, as readily as in the experiments with high external concentration of potassium ions[9]. The period of half entrance is here also about 40 min., though the water alone (Curve *A*) seems to enter a little more slowly than before, and its half-period is about 9–10 min. Taking about 30 min. as the true half-period of entrance of the potassium chloride, it may be reckoned that 1·38 mol./kgm./hr. enter the

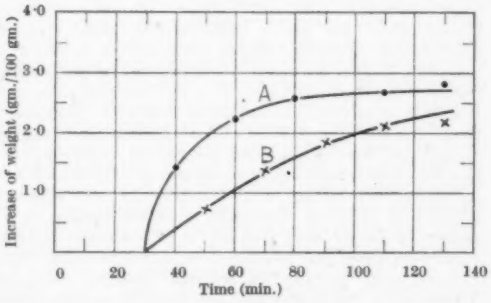

Fig. 1.

fibres per unit concentration-difference across the membrane. Assuming that this likewise applies to the sartorius *in vivo*, and that sodium chloride enters as fast as potassium chloride, then the minimal energy required to excrete the sodium salt is: $RT \times 0{\cdot}08 \times 1{\cdot}38 \times 2{\cdot}3 (\log 5 + \log 50) = 350$ cal. at 17° C. The approximate concentration ratios of sodium ions and chloride ions across the membrane are 5 and 50; and the sodium chloride is taken as diffusing as if with a concentration difference of 0·080 mol. per litre to reach an equality of chemical potential.

This 350 cal. would correspond approximately to 84 c.mm./gm./hr. of oxygen, and if account be taken also of carbonate ion, it may be increased to about 80–90 c.mm. Now this is about twice as much, or more, as the whole resting muscle metabolism of winter frogs on which these experiments were conducted. Similar calculations of the energy requirement for isolated sartorii in the cold in Ringer solutions with high concentration of potassium over 24 hr. give about four times the resting metabolism at such temperatures. Realizing the very low efficiency of such excretion in general, and also that cyanide (as given below) does not affect the osmotic control of muscle by sodium ions, it may be concluded that if sodium is not excluded from normal muscle it enters only at a very minute fraction of the rate of potassium. In short, the major, if not the entire, cause of the exclusion of sodium from muscle tissue may be assigned to a membrane effect.

Krogh relies on evidence of the following kind to support his views of comparatively rapid extrusion of sodium from muscle. Much significance is attached to Heppel's experiments on rats on a diet very low in potassium[10,11]. In these, sodium slowly enters the fibres, and can then exchange rapidly with isotopic sodium. The reversibility of this process does not appear to have been demonstrated (though for this Höber erroneously refers to Heppel's papers[10,11]). Heppel's results may be interpreted in a similar way to that of the entrance of sodium ions into the fibres of sartorii immersed in ordinary Ringer solution. Such entrance is not reversible (as dealt with below) and appears to arise from some inadequacy of the medium or the conditions; also, the fact that small increases of sodium ions and loss of potassium ions by muscle fibres during work and the reversal in a resting phase[12] may be explained otherwise than by entrance of sodium within the fibre and its active extrusion.

In his criticism Höber refers to diminution of excitability and other effects in sartorii, mentioned by Hegnauer, Fenn and Cobb[13], when immersed in Ringer solution with high content of potassium, and thinks that an anion permeability may then be established. Anion impermeability of sartorii in ordinary Ringer solutions is disproved by the experiments described above, as it is for skeletal muscle in live rats by the experiments of Wilde[14]. Höber also mentions that Fenn and Cobb's experiments[15] showed occasional swelling due to potassium chloride, as if the salt had a specific swelling power. This indicates a misunderstanding of the nature of the effect of potassium chloride discussed at some length in the paper of Boyle and Conway[3]. Potassium chloride causes swelling just as urea does if this be substituted for sodium chloride in isotonic Ringer solutions. There is no swelling when the sodium is maintained constant in the external solution.

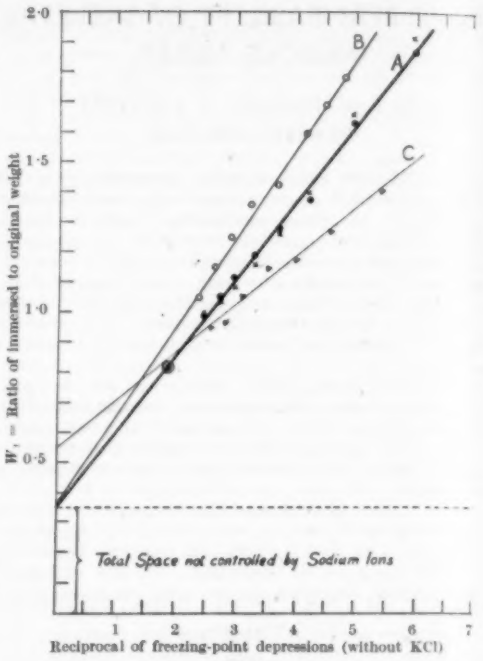

Fig. 2.

Volume control of muscle by sodium ions. From previous considerations[3] the following equation may be written for the sartorius:

$$W_1 = 0{\cdot}67\, R\, (\eta + \varepsilon) + a, \quad . \quad . \quad (1)$$

where R may be expressed as the reciprocal of the sodium ion concentration, or somewhat more accurately as the reciprocal of the freezing-point depression of the Ringer solution minus its potassium chloride concentration. In equation 1, W_1 is the ratio of the immersed weight to the original weight, η the non-diffusible material in one litre of the 'fibre water' of the fresh muscle, and ε the surplus of negative charges on η.

Fig. 2 (*A*) shows the regression line for seventy sets of four sartorii, immersed in isotonic Ringer solutions (24 hr. at 3° C.), the sodium chloride being replaced by potassium chloride (beginning with a potassium chloride value of 20 m.eq./litre). (The large circle gives the mean for a few sets with a high sodium chloride content in the external fluid.) The crosses give the results of thirty-two sets with constant potassium chloride concentration (20 m.eq. per litre), the sodium chloride concentration being varied. The line cuts the ordinate at 0·345, representing the fraction of the muscle unaffected by change of concentration of sodium ions. *This is close to the theoretical value of 0·20 dry weight plus 0·13 interspace*[3]. The slope of the line is independent of the concentration of potassium ions (when this is beyond the maintenance value). With this curve it is of interest to compare a similar line (Fig. 2,*B*) for thirty-two sets of sartorii in similar immersion fluids, but containing 2×10^{-3} *N* cyanide. The ordinate is cut at practically the same point, but the slope is slightly steeper, showing the formation of extra non-diffusible molecules within the fibres. The presence of the cyanide

ions, however, in no sense lessens the control effect of the external sodium ion concentration.

Entrance of sodium ions into the fibres in potassium-free Ringer solution, and the effect of the concentration of sodium ions on volume control. Immersion of sartorii in potassium-free Ringer solution (122 mol. sodium chloride per litre) for 24 hr. at 3° C. causes a mean increase of sodium ion concentration of 24 m.eq./kgm. of the original weight. Re-immersion for 8–24 hr. in isotonic solutions with potassium chloride substituted for sodium chloride (beginning with 20 m.eq. potassium chloride per litre) results in the line *C* of Fig. 2. This line cuts the ordinate at 0·55. *Re-immersion in the high-potassium Ringer solution stops the entrance of sodium ions but does not reverse it,* as shown in the following table :

Mean sodium of fresh muscle (m.eq./kgm.)	Mean sodium in muscle after 24 hr. in K-free sol. cont. 122 m.eq. NaCl/l. (m.eq./kgm.)	Mean sodium in muscle after re-immersion in K-Ringer with 122 m.eq. NaCl/l.		KCl added to the Ringer fluid (m.eq./l.)
		8 hr.	24 hr.	
23·9	46·9	55·3	50·1	10
	51·5	46·9	48·7	30
	44·8	42·4	39·5	60
	45·8	43·3	50·0	90
	Av. 47·2	47·0	47·1	

(Each figure is the mean of four or more results.)

All the sodium that has entered the fibres in the potassium-free Ringer comes out again very readily when the re-immersions are conducted in isotonic Ringer fluids with increasing potassium chloride and decreasing sodium chloride. A satisfactory explanation of such facts at present would appear to be that a number of fibres lose their usual permeability, allowing sodium ions to pass through as freely as potassium ions. Into the water of such fibres sodium ions should enter to the extent of approximately 24 m.eq. per litre, plus about 2 m.eq. extra as inter-space allowance, since the external sodium ion concentration is somewhat higher than the plasma value. The increase actually found was 47·2 − 23·9 = 23·3 m.eq. per kgm.

Such experiments would appear to invalidate the conclusions of Steinbach[16] (who has incorrectly presented my views in a recent paper[17]). We have, besides, conducted a very large series of experiments at room temperature and in the cold, copying Steinbach's conditions as closely as possible, but have consistently failed to obtain the reversibility he describes for the entrance of sodium ions into the fibres.

Factors determining the free passage of ions through the muscle fibre membrane. Only some points can be briefly indicated. Lipoid solubility would seem to have little if anything to do with the passage of small ions or of water across the membrane. Thus, the order of passage for water, potassium chloride and urea is as 5 (or more) : 1·0 : 1·1 ; but the partition coefficient of urea with respect to fatty oils (and water) may be shown to be about 100 times greater than that for potassium chloride, if we suppose that a real value can be attached to the latter. We may also assume that it is very much greater than that for water itself. All the ions that freely enter the muscle fibres are below a certain size-level. It is therefore strongly suggested that these enter through molecular pores. But, below a certain size-level, large differences in rates of entrance can occur, and besides the ion size, other factors appear to be called into play, such as ion shape and deformability.

A dehydration hypothesis. It may be pointed out that if we regard the relatively much greater hydration of sodium (related to its ionic potential) as affording an adequate basis for membrane discrimination between it and potassium, an active process of dehydration of sodium could in turn conceivably provide a mechanism for a very slow extrusion. It would perhaps also help to explain some cases emphasized by Krogh[7], in which sodium ions appear to traverse living membranes faster than potassium ions. (This hypothesis has also been independently suggested to me by Prof. Fearon.)

In the above account the mode of entrance of magnesium into cells has not been dealt with, nor indeed the large number of inorganic trace elements. It is assumed that such can pass through the membrane slowly, not as inorganic ions, but by complex-formation showing lipoid solubility, or entering in some way into the membrane structure.

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BRITISH PREHISTORIC ARCHÆOLOGY : RECENT AIMS, METHODS AND RESULTS*

By C. F. C. HAWKES
British Museum

THE aims of prehistoric archæology are, broadly, to give an account of the nature and activities of man where no written history is yet available, defined both in time and space and in character. The definition in time first began to take shape about a hundred years ago ; the vital importance of that in space has been recognized principally during the last twenty-five years, when a geographical approach has been seen to be indispensable to inquiries into matters both of time and of the character of prehistoric culture. These inquiries may be made either primarily from the 'historical' point of view, or primarily from the 'anthropological', aiming beyond simple definition in time and space at the fullest possible presentation of prehistoric cultural character. Each point of view has its appropriate methods, and, being essentially complementary, the two are accustomed to converge in the attainment of results ; but roughly speaking the 'historical' approach, which is the older established and uses the more purely archæological

* Summary of a discourse delivered to the Royal Institution on March 22.

methods, has in Britain provided the broad framework of the prehistoric story, while for the improvement and refinement of the framework, and for most of the purposes also of the newer or 'anthropological' approach, a wider range of methods has been called into being, variously involving the collaboration of archæology with the natural sciences. The present illustration of this will be divided between the pre-Roman Iron Age, the Bronze and New Stone or Neolithic Ages, and the Middle and Old Stone or Mesolithic and Palæolithic Ages: the broad outline given first, and then a selection of recent developments within it.

Iron Age

The latest pre-Roman immigrants into Britain were the Belgic peoples of the south-east and south, with other arrivals from across the Channel farther west, all in the first century B.C. So far back as the third century B.C. the latter had been preceded by earlier Celtic incomings, less compact, but resulting in several strong patches and a wide further scatter of immigrants, mainly a war-like and art-loving aristocracy ruling over the more solid mass of the Iron Age Celtic population, which already earlier, approximately in the fifth century B.C., had come over to settle over all the south and east, with considerable fringes beyond, and which provided the original and basic culture of the whole period. The archæological material documenting this sequence is fairly well determined, but its further study is proceeding in a number of directions, often in co-operation with the physical sciences (for example, spectrographic analysis of metals and metallurgical equipment) and with various technological studies. But wider results are being obtained by field research and excavation.

The question of towns and fortifications has attracted much attention. How far can the fortified towns of the Roman period be shown to have had genuine native antecedents? Both at Verulamium by St. Albans and at Colchester, Roman towns have been shown to adjoin the sites of capital settlements of the Belgic peoples; but these appear, particularly in the latter case where the enclosing fortifications spread over many miles, to have covered large tracts of ground in an intermittent and patchwork manner, very unlike the concentrated urban planning of Roman times. This result of modern field-work has to be compared with that of the many trial-excavations conducted in the hill-forts or 'camps' of the British Iron Age, which as a class have their beginnings already in the original phase of settlement. That is, broadly, that these strongholds were quite often only inhabited intermittently, or used as fortified refuges in time of trouble, but that in the later phases of the Age, and above all in the last phases (contemporary with Belgic Verulamium and Colchester), some of them certainly were inhabited intensively enough to deserve the name, if not of towns, then at least of fortified capital villages. The most impressive of these is Maiden Castle in Dorset, where to the sequence of occupation there corresponds the successive enlargement and strengthening of the huge earthworks defending it: at first enclosing the eastern portion of the hill only, they were later extended to enclose the whole. The form of such successions varies at different sites; at Bury Hill near Andover the site of a large and simple earlier fort lay derelict for at least a century before the building of a smaller but stronger one. This result was obtained by test-sections cut where the two sets of earthworks overlapped; and the minimum duration of the interval was estimated from soil-analysis of the turf-line between them—one example, out of many that could be given, of the co-operation between archæology and soil-science, from which a wide range of important results may be expected in the future. The history of hill-forts in Britain thus varies much from site to site; and if whole groups of them are investigated and the findings collated for the entire area—as has been done for the Sussex Downs—the composite picture obtained will be of value not only historically, but also as a starting-point for assessing the character of the area's communal life throughout the period.

But for that assessment the evidence of fortified sites must be brought together with that of the homesteads and villages of the open country. The 'villas', familiar as the chief units of rural economy in Roman times, have sometimes, in the south-east, been found to overlie the remains of Belgic habitations, and though their always 'civilized' architecture, with its rectangular ground-plans, was a Roman innovation—a radical change from the round or oval design of most prehistoric dwellings in Britain—yet their character of a substantial single homestead has its roots not only in pre-Roman but in pre-Belgic times. For whereas older methods of excavating and interpreting Iron Age rural sites left it to be supposed that these were usually villages of numerous small dwellings, thought often to be represented by the pits with which such sites are commonly studded, the excavations at Little Woodbury near Salisbury have proved that such pits were storage-pits, and that the site was essentially a large single homestead, datable onwards from the third century B.C. The house has been planned and 'reconstructed' from the post-holes that held its timber uprights, and was a circular building with a roof sloping up to a central four-posted core, and with an outer verandah or aisle running round it under the eaves. Simpler and variant forms of the type are known elsewhere, in the west and north mainly dry-built in stone; some regions and phases of the period, on the other hand, display the alternative type in which the floor is somewhat sunk into the ground and walls and roof are formed in one, of more or less pliant stakes or boughs, embedded around the floor-margin and arched over and woven together above like an inverted basket. The satisfactory excavation of either type needs careful work; but without this, or without clearly visible remains of stone-built structures, it cannot safely be decided whether any given site is a single homestead or a true village, since the Iron Age had both—just as in Roman times there were both 'villas' and villages.

Photography from the air, as has now become well known, is of very great assistance in locating such sites and giving a rough overall plan, whether it reveal them by picking out their contours in the turf, or by showing up the pattern of differential growth and coloration which their remains impart to crops in the overlying soil. It is also of great value when applied to earthworks and other major ancient features of the country; and particularly to the systems of fields tilled in Roman and prehistoric times and traceable from their delimiting scarps and banks, or 'lynchets'. These 'Celtic fields' are commonly small and squarish, implying cultivation by a light or two-ox plough; another sort, longer and more strip-like, has been associated with the heavier plough-teams employed in Britain first by the Belgæ and then on (probably many) Roman 'villa'-farms;

but it appears also earlier and in non-Belgic districts, so that its full history has yet to be made out. All this research into the 'anthropology' and agrarian life and institutions of pre-Roman Britain shows how archæology can widen its aims and methods to give ever more vivid and precise results. But the importance of the 'historical' framework of course remains; indeed, in any case in southern Britain, the Iron Age pattern of life is now known to have been taking shape already in the last centuries of the Bronze Age.

Bronze and Neolithic Ages

Those last centuries, after 1000 B.C. and running on into the Iron Age some five or more centuries later, were in fact marked by immigrations which appear as forerunners of those of the Iron Age peoples. In the 'transition' between the two Ages, they affected the north more than was formerly suspected; while the central fact of the southern Late Bronze Age was the incoming of people from north-west Europe whose cultural tradition had long been maturing on the Continent independently (in the main) of the insular Middle Bronze Age tradition of Britain. This latter tradition had had a long life, going back centuries beyond 1000 B.C. to the Early Bronze Age, when its constituent elements were formed by another complex of immigrations, acting upon native populations still earlier established. The tradition included some agriculture, but was predominantly pastoral, with cattle as the main primary source of subsistence and wealth. The craft of bronze-working cannot be considered here, but was of a high order, and in the Late Bronze Age expanded its production and commerce greatly; flint and stone working went on beside it; and in pottery, the best-known products are the urns containing the remains of the cremated dead. The native Middle Bronze Age urns, quite unlike those of the Late Bronze Age immigrants, have their closest prototypes in the so-called 'Food-vessel' pottery, which reflects the Early Bronze Age mixture between immigrants and natives. Of the immigrants the most numerous and widespread were the various 'Beaker' peoples, so called from their distinctive drinking-cups, who arrived shortly before and after 1800 B.C.: the natives were the peoples who had carried the culture of the Neolithic Age, from its various beginnings in the centuries before. In addition to the group to be noticed below in connexion with Skara Brae in Orkney, one group of these were mainly hunters, fishers, and herdsmen, and of North-European affinity, while the other series of groups represent the great West-European family of peoples whose original Neolithic economy, an outgrowth from the civilization of the ancient East, brought agriculture and stock-farming for the first time to the British Isles, between about 2500 and 2300 B.C.

The Neolithic flint and stone and other industries and the beginnings of metal-working must here be passed over; but before the Neolithic and Bronze Age peoples' mode of life is considered, their tombs and religious monuments must engage attention, for these are much more conspicuous among their remains than those of the later peoples, no doubt because, at their stage of development, supernatural agencies played a more compelling part in their general conceptions. Of the Bronze Age, the most familiar monuments are the 'round barrows' erected over the graves of the more important dead: common in many districts, their known numbers have been greatly added to by air-photographic detection of examples flattened by modern ploughing.

Great strides have also recently been made in the technique of their excavation. As well as the mere recovery of the grave-deposit, the modern excavator aims at the study of the entire structure of the barrow, as a complex monument embodying ritual prescriptions which have much to reveal of the people's culture and ideas. The method is to divide the barrow into quadrants, and so to excavate it as to obtain precise information of its various features in all three of their dimensions. The features may include secondary added to primary interments, various forms of grave, and enclosure-rings of various kinds beneath or around the barrow: of piled or earth-fast stones, of embedded timber uprights, or of driven stakes to carry wattled fencing; also a surrounding ditch, and a variety of outward forms given to the barrow-mass itself. The details of these and other features must be elucidated with the help of scientific specialists, for example, for the geology and petrology, for timber remains, charcoal and other burnt matter, and for structural earth- and turf-work; and from all this a body of knowledge is being gradually built up, which will presently make the religious tomb-practices of the Bronze Age matters no longer of speculation but of ascertainment.

For the Neolithic, the tombs of the Western colonists may often be made no less informative. In the main, they are more impressive structurally, whether it be the 'long barrows' of the south and east, of earthwork with features of turf and timber and sometimes stone, or the essentially stone-built 'megalithic' tombs of the west and north, which in the Severn and Cotswold region are in fact long barrows chambered and walled in stone, and elsewhere variously passage- or gallery- or cist-tombs or 'dolmens': all have had devoted to them a care and labour which shows that the form of fertility religion which came westward with this culture from the East was intensely concerned with the supernatural power of the dead to make or mar the welfare of the living, and with the ritual and magic required accordingly at these tombs, in the chambers of which the burials are found not singly, but grouped collectively or in succession together. Examples from the Cotswolds show only some of the many details which meticulous excavation can reveal; and here again, the more scientific archæology makes its methods, the more effectively it will contribute to human studies, in the anthropology of ancient religious observance.

The same is true of the investigation of the famous stone circles of Britain which, with 'avenues' and other standing-stone monuments, and with the cognate timber circles disclosed by air-photography and excavation, took their rise in the period of the 'Beaker' and other Early Bronze Age invasions, and are thus only partly connected with the ideas of megalithic tomb-building. The work of recent years at Avebury has here been of particular importance; and as regards the timber circles, 'reconstruction' has begun to entertain the notion that some at least of them were roofed, as would befit the climate of these northern latitudes where they were developed. Thus the 'houses' of the unseen powers imagined by prehistoric man may be brought into type-relation with the houses of prehistoric man himself.

Unfortunately, the actual houses of Neolithic and Bronze Age man in Britain have not yet been explored in any great numbers. Generalizations about their

type and character must await the excavations of more examples and will therefore here be passed over, along with any that can be propounded about the rural economy of small-scale tillage and larger-scale cattle-keeping—with which the so-called 'Neolithic camps' seem especially associated—whereby these peoples lived. But the site of Skara Brae in Orkney, the stone hut-villages, clustered in the sand-dunes, of a remote late-Neolithic community, deserves special notice for its wonderful preservation of the interior fittings and furnishings of the houses, which, the islands being virtually treeless but rich in flat-splitting flagstone forming an indestructible substitute for joinery, have been found intact beneath the covering sand, and show how much we are entitled to imagine of the perished equipment of Neolithic or Bronze Age life in normal wood-using localities.

It remains to point out that scientific collaboration in the archæology of these periods is not confined to the study of materials and structures, but through research into physical environment and climate has contributed greatly to the 'historical' framework. Bronze Age and Neolithic objects found suitably stratified in sedimentary deposits, and most especially in peat, can be dated in terms of the environmental and climatic history determined for the whole deposit sequence by geological, faunistic, and palæobotanical investigation. In Wales and the west of England, no less than in Ireland, this originally Scandinavian technique has been successfully applied; and the classic English region for its application is the Fens, where a continuous sequence has been worked out extending right through these Ages (with an especially important horizon of clay indicating a transgression of the sea in the period of the 'Beaker' invasions), from the preceding Mesolithic or Middle Stone Age—which the subject thus introduces next for brief attention.

Mesolithic and Palæolithic Ages

On its geological and faunistic sides, the technique of determining 'natural chronology' is in general principles the same for the Holocene phases covering the Mesolithic as for the Pleistocene covering the Palæolithic; on the palæobotanist's side, its essential method is the pollen-analysis of stratified peats and sediments, recording their content of the pollen of different trees and plants progressively from the bottom to the top of the section examined, and so making the history of vegetation reveal that of climate. Where an archæological object or horizon of human occupation occurs in the section, it can thus be fitted into place, and the web of cross-correlations so made between environmental and archæological type-sequences enables time-recording to be taken back far beyond the scope of archæology working unaided from types of implements, or of pottery, dated already in better documented regions. At the same time, this knowledge of environment throws much light upon the conditions in which the people of any given archæological period subsisted.

These 'combined operations' of archæology and natural science have illumined all the stages of the north European and British Mesolithic, covering the thousands of years from the end of the geological Pleistocene to the age of the Neolithic colonizations. But pure archæology has also its part to play: simple hunters and gatherers as they were, the Mesolithic peoples have left distinctive features of their communal culture, not only in their flint and bone-work but sometimes in their dwellings, some of which, with floors scooped as pits into their favourite sand or gravel soil, have been found and excavated, notably a group near Farnham in Surrey. In East and Central Europe such dwellings have been dated right back to Palæolithic times, and that may be done one day in Britain too.

At present, our known Palæolithic occupation sites consist of caves (in the west, and the southern Pennines) and occasional open 'floors' for camping or flint-working, which may, like the much more numerous occurrences of flint artifacts by themselves, be geologically stratified. For the Palæolithic, indeed, the geologist becomes master of the whole field of chronology, essential for controlling the archæological classification of the artifacts into industries and cultures. As the geological evidence gradually reveals itself, the story of Palæolithic man, and its relationship to the slow fluctuation of the Pleistocene climate between its recurrent glacial and temperate phases, is gradually unfolding. The pace of progress depends on the geologists, and it is natural that where interpretation is so difficult, unanimity among them should not be easily forthcoming. This is not to be cozened by archæological theorizing meanwhile. But continual progress is being made; and indeed for every prehistoric age, archæology in Britain should be able to look forward to a continual winning of results, as its methods improve and its aims pierce further. It is beginning to reach its maturity, but it has plenty yet to do.

PHYSIOLOGY OF FERTILIZATION

By Lord ROTHSCHILD
Zoological Laboratory, Cambridge

EXPERIMENTS have revealed a surprising and discouraging lack of uniformity in the physiological signs of fertilization in different types of eggs. In sea-urchin eggs, oxygen consumption increases after fertilization[1]; in *Cumingia* and *Chætopterus* eggs, oxygen consumption is stated to decrease after fertilization[2], though this might be due to acid production masking an increase in oxygen consumption. Acid production during the fertilization reaction, first noted by Ashbel[3], has only been reported in sea-urchin eggs, though as Gray first pointed out, the sudden evolution of carbon dioxide which results from the interaction of this acid and the bicarbonate in the sea water may mask the true oxygen consumption if the carbon dioxide absorbent does not act quickly enough. The experimenter may therefore miss the acid production and 'measure' a low oxygen consumption-rate.

Biophysical measurements, involving the resistance, capacitance, and potential across the egg membrane before and after fertilization, have not been sufficiently numerous to merit much attention as yet, though they too have failed to reveal any common denominator in the fertilization reaction.

One of the most characteristic features of the fertilization reaction is the block to polyspermy. Though there are certain exceptions which are discussed later, the rule is that only one spermatozoon fertilizes an egg. Describing this phenomenon, Just says[4]: "Before the actual elevation of the [fertilization] membrane, some cortical change, beginning at the point of sperm entry, sweeps over the egg immunizing it to other sperm; the direct opposite pole of the site of sperm entry is the last point affected".

The mere fact that most eggs are monospermic necessitates some reaction of this type, and as the surface of the egg could not alter simultaneously all over, some change, originating at the site of attachment of the spermatozoon, must be propagated over the egg surface or perhaps through the egg. As Just says, the whole reaction is over *before* the fertilization membrane appears, showing that this latter has nothing to do with the block to polyspermy. The possibility that this sperm-repelling wave might be associated with electrical changes similar to those observed in nerve, muscle, and certain cable-like plant cells such as *Nitella* has occurred to several experimenters, and a brief note on certain electrical disturbances associated with fertilization and traumatic parthenogenesis in the frog's egg was published in *Nature*[5]. Experiments of this type present such technical difficulties however, when the frog's egg is the biological material, that it is doubtful if much value can be attached to them until they are systematically repeated.

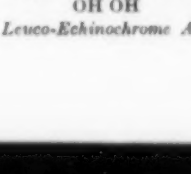
The assumption that this sperm-repelling wave* exists has certain consequences :

(*a*) Unless the propagation-rate increases with the size of the egg, large eggs should tend to be polyspermic. This would seem to be the case, as in bird[6] and reptile[7] eggs polyspermy is fairly common.

(*b*) Some eggs can be induced to be polyspermic by the simple procedure of over-insemination. In dispermic eggs, there should be a preponderance of cases where the two spermatozoa enter the egg at approximately opposite poles or as far apart as the morphology of the egg permits, because the probability of the second spermatozoon successfully entering the egg is greatest when the angle subtended at the egg centre by the points of contact of two spermatozoa is 180°. No experiments to confirm this have been done ; they would be profitable, and from the results it might even be possible to make some estimate of the velocity at which the wave is propagated over the egg surface.

The fertilization reaction is usually specific, and it is often said that a spermatozoon of a particular species has incorporated in it a particular 'key' which only opens a particular 'lock' in the surface of an egg of the same species. Such a statement is only another way of saying that reproductive specificity is characteristic of living organisms; but the concept can be brought slightly nearer reality (that is, description in terms of physical chemistry) by a consideration of the electrostatic forces which exist in protein molecules, in which complicated configurations of electric charge may arise through different parts of the molecule having oppositely charged groups of varying electrical intensity. That such situations exist in protein molecules cannot be doubted, and in view of the number of combinations of such configurations that are possible, it is not difficult to imagine that the probability of a particular electrical sperm configuration fitting more than one particular electrical egg configuration is remote (see Verwey[8] for discussions of these forces). In certain circumstances a misfit may occur, and a shark spermatozoon may partially fertilize a sea-urchin egg, though the lock is forced rather than fitted and subsequent development is abnormal or absent. Alternatively, the configurations may be so similar in related species that a partial fit may occur. Such electrical conditions may have to be considered at distances involving Ångströms rather than micra. Moreover, an egg, like an atom, might well appear to have an electrically homogeneous surface on a macroscopic scale. When far away from the egg, say a few micra, the electrostatic patterns may have no effect on a spermatozoon. The protein molecules present an electrically neutral, or even an electrically repulsive front, to spermatozoa of other species. If, however, the right spermatozoon gets close enough and the electrostatic keys on its proteins fit the electrostatic locks on the egg proteins, the fertilization reaction begins. The actual movements of a spermatozoon not only get it into contact with the egg, but also increase the probability of a particular sperm surface fitting the appropriate egg surface. After the initial fit, the next phase must be the alteration of the egg lock, so that other sperm keys do not fit. Such changes *might* be observable by macroscopic electrical measurements, but as only very small changes would be necessary, the macroscopic effects on such parameters as capacitance, potential difference across the membrane, or ζ potential might be very small. It is easy to imagine a variety of parthenogenetic agents, whether they take the form of puncture with a needle with concomitant local depolarization, or the application of saponin, which could interfere with the electrostatic configurations of the egg proteins and thus prevent spermatozoa from doing the same thing. But for normal development to take place, the unique configurations of the specific spermatozoon are necessary for reaction with the egg nucleus.

Sea water around the ripe eggs of certain marine invertebrates contains a chemical which has an effect on spermatozoa of the same species. It increases their rate of oxygen consumption[9] and causes them to come together in clumps, a phenomenon known as agglutination. Although various chemicals such as thyroxine[10] and cinnamyl alcohol[11] can partly reproduce the effects of this egg secretion, which Lillie called fertilizin[12], it has only been positively identified in one case, and even then, in a not entirely satisfactory way. Kuhn and Wallenfels[13] extracted echinochrome *A*, 2-ethyl-pentahydroxy-naphthaquinone, a pigment derived from leuco-echinochrome *A*, 2-ethyl-hepta-hydroxynaphthalene, from the *ripe* eggs of *Arbacia pustulosa*. This substance increases the activity of spermatozoa (and therefore presumably their oxygen consumption-rate), but does not cause them to agglutinate. The substance responsible for this latter phenomenon is situated in the jelly which normally surrounds the eggs, but not in the eggs themselves. It has not so far been identified. As only ripe eggs contain echinochrome *A*, and as egg secretions are only found in the sea water around ripe eggs, it is reasonable to assume that the substance in egg secretions which activates spermatozoa is echinochrome *A* ; but this substance has not so far been positively identified in sea water around ripe eggs and its effect on spermatozoa has not been measured manometrically. Tyler[14] repeated the above-mentioned experiments on *A. pustulosa*, using spermatozoa and echinochrome of another sea-urchin, *Strongylocentrotus purpuratus*, but was unable to confirm Kuhn's results.

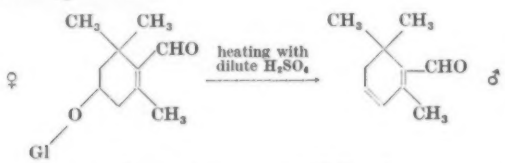


Leuco-Echinochrome A.

* In a spherical cell, the wave would probably not have such a well-defined 'shape' as in cylindrical cells.

The chemical identification of the egg secretions, even of other sea-urchin species, would be of interest, while the importance of identifying the 'fertilizins' of *Nereis* and *Fucus* eggs can scarcely be over-estimated. The same applies to the acid expelled during the fertilization reaction, which might possibly be related to fertilizin. If the fertilizins do not have characteristic absorption spectra, their concentration and identification would present almost insuperable difficulties were it not for their biological activity in increasing the oxygen consumption of spermatozoa and in exerting a chemotactic influence. Eggs are not alone in producing a substance which has an effect on the gametes of the opposite sex. There is little doubt that the semen of *Echinarachnius* and *Asterias* contains a substance which induces females to spawn, though in the case of *Nereis limbata*, the male spawns when the surrounding sea water contains egg secretions of the same species[15]. This field, which also involves chemical substances with well-defined biological effects, has not so far been explored.

The subject of fertilization can scarcely be left without some reference to the absorbing work of Kuhn and Moewus[16], who allege that they can alter the 'sex' of *Chlamydomonas eugametos f. synoica* by treatment with extracts from male and female gametes of a dicœcious strain of this alga (summarized by Heilbron[17]). The behaviour of these extracts is stated to be almost completely reproduced by the glycoside picrocrocin (probably with gentiobiose substituted for glucose), in the case of the female-forming extract, and the aglucone safranal in the case of the male-forming extract.



Picrocrocin ——→ Safranal

Experiments such as these, which involve an analysis of sexual differentiation in material which is not entirely suited to such analysis, require very careful biological examination before the interpretation of the results can be entirely accepted. A repetition of the experiments would be welcome.

Research into fertilization and parthenogenesis is still in its infancy, though the modern techniques of the organic chemist, the biochemist, and the biophysicist, have already produced valuable information in this field. Combined with the necessary biological knowledge and techniques, they can scarcely fail to produce further important results, of theoretical and applied interest, in a comparatively short time.

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OBITUARIES

Prof. E. G. Coker, F.R.S.

PROF. ERNEST GEORGE COKER, who died on April 9 in his seventy-seventh year, was well known to engineers all over the world for his work in developing a method of measurement of stress by photo-elasticity, to which he devoted many years of his distinguished career.

Prof. Coker commenced his engineering career in 1883 as a pupil under the Chief Mechanical Engineer of the London and North-Western Railway. After a few years at Crewe and Wolverton works, he went to the Royal College of Science and obtained the A.R.C.Sc. With the help of a Whitworth Exhibition and a scholarship, he went to the University of Edinburgh for an engineering course and was awarded the B.Sc. in 1892. Later he obtained the D.Sc. of that University. After a short period as assistant examiner at H.M. Patent Office, he took another engineering course, this time at Cambridge, and in 1896 gained first-class honours in the Mechanical Sciences Tripos; eventually he was granted the M.A. degree. He returned to the Patent Office for two years.

In 1898 Coker was appointed assistant professor at McGill University, Montreal, and five years later became associate professor. He returned to England in 1905 to take up the appointment of professor of mechanical engineering and applied mathematics at the City and Guilds of London Technical College, Finsbury, where he remained until 1914. During this period he was responsible for the building and equipping of a new engineering laboratory. In 1914 he became Kennedy professor of civil and mechanical engineering in the University of London, University College, where he remained until his retirement in 1934.

During his stay in Canada, Prof. Coker carried out a great deal of research work in the testing of materials and in hydraulics; but it was at Finsbury Technical College that he began to develop his main research work on photo-elasticity, which he continued at University College. The stress-optical properties of transparent materials under polarized light had been discovered by Brewster so early as 1816, and more recently attempts had been made to apply the principle to engineering problems, using models made of glass. Prof. Coker used for his experiments models made of xylonite, a material which is not brittle and is easily cut to any desired shape. He applied the method of photo-elasticity to the determination of stress distribution in many types of machine components and structural elements, devising much ingenious apparatus and establishing a standard technique. He published numerous papers on the subject, and delivered many public lectures. In collaboration with his colleague at University College, the late Prof. L. N. G. Filon, he published a comprehensive text-book entitled "Photo-Elasticity".

Prof. Coker's distinctions included the fellowship of the Royal Society, from which he received the Rumford Medal in 1936, and the fellowship of the Royal Society of Edinburgh. He was a member of the Institution of Civil Engineers and of the Institution of Mechanical Engineers. By the former he was awarded the Telford Medal in 1921 and the Howard Quinquennial Medal in 1932, and from the latter he received the Thomas Hawksley Medal in 1922.

G. T. R. HILL

Prof. T. H. Bryce, F.R.S.

By the death of Thomas Hastie Bryce in hospital at Oxford on May 16, medicine has lost one of its outstanding figures of the old school, and science a distinguished anatomist whose work will long be remembered apart from his description of the Bryce–Teacher ovum.

Prof. Bryce was the son of the late Dr. William Bryce, of Edinburgh, and he was born on October 20, 1862. He was the cousin of Lord Bryce, the learned historian and diplomat, author of "The Holy Roman Empire", "The American Commonwealth", and other standard works, who was for a period H.M. Ambassador at Washington, President of the Board of Trade, and regius professor of civil law at Oxford. T. H. Bryce received his earlier education at the Edinburgh Collegiate School, and he passed from there to the University of Edinburgh, where he had a distinguished career, graduating in arts and medicine. He gained the gold medal for his M.D. thesis. In anatomical work he was trained under Sir William Turner, and he held a post as demonstrator in the Anatomy Department at Edinburgh. In 1890 Bryce was appointed lecturer in anatomy at Queen Margaret College, Glasgow, which meant that he was virtually responsible for the anatomical training of all the women students at the University of Glasgow. Two years later he was called to the post of senior lecturer in the University Department of Anatomy under Prof. John Cleland, and he remained in that post during the following seventeen years, until he succeeded Cleland in the chair in 1909. Bryce held the chair for twenty-six years. He retired in 1935, in his seventy-third year, and received the honorary title of professor emeritus. He then went to reside at Peebles. Bryce married, in 1889, Mary Russell Landale, daughter of Mr. George Wilson, of Dalmarnock. Mrs. Bryce died in 1934. She had a notable career as an artist and embroiderer, and an excellent example of her work can be seen in the Memorial Chapel at the University of Glasgow. Her personal kindness and charm brought her many friends. They had one son, Major W. J. P. Bryce, with whom Prof. Bryce was residing at Lechlade-on-Thames, Gloucestershire, until his last illness.

Prof. Bryce was elected a fellow of the Royal Society in 1922. In 1906 he was awarded the Keith Prize of the Royal Society of Edinburgh, and he was also a fellow of that Society. The University of Glasgow conferred upon him the honorary degree of LL.D. In 1908 he was appointed a member of the Royal Commission on Ancient Monuments in Scotland, and on it he did active work almost until his death.

Although Bryce contributed papers on descriptive anatomy to the journals, it was as an embryologist and anthropologist that he was best known. What must have been one of his earliest papers—if not his earliest—dealt with the anatomy and mechanism of the wrist joint reviewed in the light of a series of Röntgen-ray photographs of the living hand. This paper appeared very soon after Röntgen's announcement of his discovery. In the first decade of the century, Bryce made a number of important contributions to the young science of embryology. In 1904 he showed that the original mesenchyme cells of the spleen rudiment in *Lepidosiren* are differentiated into both red and white blood corpuscles, thus demonstrating that in the lower vertebrates the spleen is an active hæmopoietic organ. In the following year he showed that in *Lepidosiren* the spleen arises as a condensation of the mesenchyme of the gut wall, and he traced the development of the vascular relations of the spleen. In 1906 he turned his attention to the branchial buds of *Lepidosiren*, and showed that the dorsal buds III and IV develop into the thymus, while buds II and V undergo no further development. Other important contributions dealt with the division of primitive blood cells in *Lepidosiren*, the histogenesis of nerves and the development of spinal nerve roots. In the field of embryology, however, Bryce's name is perhaps best known in connexion with his work on the mechanism of fertilization and on the embedding and early development of the human ovum. With Prof. J. H. Teacher he wrote a classic work on this subject (1908), and in this the authors described a very early human ovum which soon assumed an important place in the history of embryology.

Along with Sir E. A. Shäfer and Prof. Johnson Symington, Bryce edited the various volumes of the eleventh edition of Quain's monumental "Elements of Anatomy", and he himself wrote three of the volumes. The volume on "Embryology" (vol. 1) was the first to appear, in 1908. In the short space of 260 pages of text Bryce gave a masterly exposition of the science of human embryology and also of its historical development in more recent times. The work was no mere compilation, since it embodied the researches of its author, and contained numerous original illustrations which had not been previously published. Bryce also wrote that volume of "Quain" which dealt with "Osteology and Arthrology" (1915, Vol. 4, Part 1). This volume is also important in that it gives its author's views regarding a number of salient questions in physical anthropology. The third volume written by Bryce was that on "Myology" (1923, Vol. 4, Part 2).

Prof. Bryce was also a distinguished anthropologist and an archæologist of no mean calibre. His work on physical anthropology is distributed in the journals. In 1910 he published "The Book of Arran, Prehistoric Cultural Remains". He was president of the Glasgow Archæological Society, and at various periods a vice-president of the Society of Antiquaries of Scotland. As honorary curator of the Hunterian Museum in the University of Glasgow, he did much to make known this great collection. His excavations of Bronze Age graves in Bute and Arran were models of technique, and almost to the last he studied sepulchral monuments in Shetland.

As a teacher Bryce will be remembered, by those who took only the medical curriculum, mainly for his kindliness and geniality. Although his lectures to medicals were characterized by the promise of wider horizons which they contained, he left it to his senior lecturers to grind into the students the apparently limitless details of descriptive anatomy. The number of his pupils who have distinguished themselves and occupied chairs of anatomy will bear witness to the success and inspiration of Bryce's leadership. It was really those students who —like the writer—sat at the feet of Bryce in the higher classes of embryology and of physical anthropology respectively, designed for those taking anatomy as a principal subject in a science degree, and worked under his immediate supervision in his embryological laboratory, who could appreciate the range of his interests, the depth of his knowledge, and the generosity of his views on the work of scientific colleagues, with whom he did not always agree. He

possessed a fine collection of sections of early embryos, all cut and stained by himself. I well remember the wistful sadness which crept into his voice as he once told me of a solitary gap in one very long series of slides. Bryce was staining one of these huge slides when his wife came in and informed him that she had lost her purse. Bryce laid the slide on the bench for a few moments while he spoke to her, and when he picked it up again he discovered to his horror that he had put the slide down with the sections next the wood. Alas! the precious slide was ruined. As Bryce said, "The purse turned up all right, but my sections —well, I couldn't replace *them*".

Prof. Bryce was an active golfer and a keen fisherman. He was also a microscopical artist of the highest calibre. The numerous beautiful illustrations from his pencil in Quain's "Embryology" bear witness to the quality of his skill in this difficult form of art.

E. Ashworth Underwood

Mr. E. G. Boulenger

The sudden death of Edward George Boulenger at the early age of fifty-seven came as a shock to his many friends and especially to his old colleagues at the London Zoo, and at the Savile Club where he was a well-known and popular member. A week before his death, on April 30, he had been working in the library at the Zoo, taking notes for a book on popular zoology on which he was engaged. He then seemed in the best of spirits and was obviously enjoying his well-earned retirement at Polperro in Cornwall, devoting himself to writing, the contemplation of wild life, and the entertainment of his friends, among whom his hospitality was a byword. His fund of stories and anecdotes was inexhaustible, and his knowledge of food and wine and his ready wit made him a most agreeable host.

Boulenger's knowledge of the exhibition of reptiles, amphibians and fishes and the conditions necessary to their well-being in captivity was unrivalled. In this respect he was the perfect showman. His name will always be associated at the Zoo with the great freshwater and sea-water Aquarium which was opened in 1924. Previous to this he had been curator of reptiles for thirteen years, a post in which he was succeeded by Miss Joan Procter when he took up the directorship of the Aquarium. In 1938, on the retirement of Dr. Burgess Barnett, who had succeeded Miss Procter on her death in 1931, Boulenger took over the Reptile House again and ran it in conjunction with the Aquarium until the outbreak of war. In the "Centenary History" of the Zoo published in 1929, Sir Peter Chalmers Mitchell paid tribute to Boulenger in these words: "The Society owes its unique Aquarium in large measure to the knowledge, perseverance and enthusiasm of one person, Mr. E. G. Boulenger, now its Director".

Like many other buildings in the Gardens, Boulenger's Aquarium suffered during the Second World War as the result of bombing, but the fresh-water section has already been repaired, and it is hoped that the sea-water and tropical sections will be opened by the end of the year in their original form. The Aquarium stands as a lasting monument to Boulenger's vigorous efforts and creative ability; his name is certainly one of those outstanding in the history of the Zoo.

Boulenger was a good linguist, speaking both French and German. This stood him in excellent stead on the many journeys he made to the Continent and elsewhere in search of interesting specimens for the Aquarium and Reptile House. He was educated at St. Paul's School, but owed a great deal of his knowledge of reptiles to his father, the late G. A. Boulenger, who was for many years the greatest living authority on cold-blooded vertebrates. He served in both the First and Second World Wars—in the first as an observer in the Balloon Section of the Royal Flying Corps, and in the second as a major on the General Staff at the War Office. He had a facile pen and in addition to many semi-scientific papers and articles on reptiles and fishes, he found time to publish several books dealing with animals, among which "A Naturalist at the Dinner Table", "A Naturalist at the Zoo", and "Apes and Monkeys" will be best remembered.

Edward Boulenger's death, following as it does so closely on that of his old chief, Sir Peter Chalmers Mitchell, with whom he worked so long, brings to a colleague a flood of memories of days and sometimes nights of hard work, made easy by the sense of achievement and ultimate triumph over many difficulties.

Geoffrey M. Vevers

Mr. C. A. Watts

The death occurred on May 15 of Mr. Charles Albert Watts, founder of C. A. Watts and Co., Ltd., and the Rationalist Press Association, Ltd. Born in 1858, he was the son of Charles Watts, an intimate colleague of Charles Bradlaugh, G. J. Holyoake and other reformers. At the age of twelve he was apprenticed to Austin Holyoake, who printed Bradlaugh's publications; and shortly after the death of Holyoake, Watts, though still in his teens, took sole charge of the printing business and began to initiate publishing ventures, chiefly in the field of advanced thought in religion and philosophy.

In the eighties and nineties the dissemination of books of this type was attended by many difficulties, not the least of which was the reluctance of the distributing trades to handle and display works which challenged the traditional religious outlook. Mr. Watts set himself to overcome these difficulties by founding the Rationalist Press Association, Ltd., with a double purpose: to provide funds which would enable original works and reprints to be issued at moderate prices; secondly, to create close relations with potential buyers. It scored its first success by issuing sixpenny reprints of the chief works of Spencer, Darwin, T. H. Huxley, Tyndall and others at a time when this type of production was confined to fiction of established popularity. These reprints later developed into the now well-known Thinker's Library, consisting of small handy volumes on fundamental problems of philosophy, religion and science, which has achieved a distinctive position in modern thought.

We regret to announce the following deaths:

Sir Charles Marston, known for his interest in archæological exploration in Egypt and the Middle East, on May 21, aged seventy-nine.

Prof. J. W. W. Stephens, F.R.S., emeritus professor of tropical medicine in the University of Liverpool, on May 17, aged eighty.

NEWS and VIEWS

Scientific Committee on Man-power

THE White Paper on Scientific Man-power, which will be dealt with in forthcoming issues of *Nature*, was published on May 27 (H.M. Stationery Office, 6*d*. net). The Lord President of the Council, Mr. Herbert Morrison, in reply to a question by Mr. Phillips Price, in the House of Commons on that day said that the Committee's report "makes a strong case for a very substantial expansion in the output of qualified scientists from the universities at the earliest possible date. The Government are in general agreement with the conclusions of the Committee, which we recognize will involve a substantial liability on the Exchequer. We hope that they will receive the immediate and serious consideration of the university authorities, so that detailed proposals for giving effect to them can be formulated in consultation with the University Grants Committee". The constitution of the Committee was published in *Nature* of December 8, 1945, p. 686.

Royal Society Empire Scientific Conference

THE Royal Society Empire Scientific Conference, which is being held during June 17–July 8, will be opened by the King at a meeting to be held at 11 a.m. on June 17 in the Senate House of the University of London. Meetings will be held in London (June 17–19 and July 6 and 8), Cambridge (June 22–28) and Oxford (July 1–4). Among the topics to be discussed are: general scientific organisation; the interchange of scientific workers throughout the British Empire; natural products of the Empire and related chemical industries; agricultural science in the Empire; mineral resources; standards of measurement, units and symbols; collection and interchange of scientific records and material; scientific information service; etiology and control of infectious and transmissible diseases; physiological and psychological factors under tropical conditions and in industry; mapping and exploration by air; nutrition; land utilization and conservation; Empire co-operation in the scientific field with international organisations; scientific news for the public.

Atomic Scientists' Association

DURING the autumn of 1945 an Atomic Scientists' Committee was formed under the auspices of, but not affiliated to, the Association of Scientific Workers. This Committee was concerned with discussion of the policies which scientific workers might reasonably adopt over matters arising out of the control of atomic energy, the question of secrecy in fundamental scientific research and other related problems. In addition, the Committee undertook to a limited extent to inform the general public through the writing of pamphlets and the addressing of meetings. Independent groups of atomic scientists with similar aims had sprung up elsewhere, particularly in Liverpool and Oxford. In view of the urgency of the present world situation, on February 28 a meeting was called of the Atomic Scientists' Committee, together with representatives of the independent groups, at which it was decided to dissolve the Committee and form an independent association to be called the Atomic Scientists' Association, embracing graduates in pure and applied science who have been associated with atomic energy projects in Great Britain or in Canada or the United States, and who are willing to give time and effort to the furtherance of the aims of the Association.

The aims of the Association are as follows: (1) To provide a forum for the discussion among men of science of the scientific, social and international problems arising out of the release of atomic energy. (2) To keep these problems before the public and to press for a positive political programme for their solution. (3) To disseminate and explain published material on atomic energy and particularly on its implications both to other men of science and to the general public; also to provide an agency for the countering of misleading statements. (4) To make and maintain contact with scientific and other bodies in Britain with which some aim is held in common. (5) To form and maintain a library of books, papers and other publications relating to the above objects.

A provisional committee has been set up, consisting of the following members: Prof. H. S. W. Massey (chairman); Dr. G. O. Jones, Prof. R. E. Peierls, Dr. J. Rotblat, Dr. S. Devons, with Dr. W. J. Arrol and Dr. E. H. S. Burhop as joint honorary secretaries. The first annual general meeting of the Association will be held on June 15 at the University of Birmingham, Edmund Street, Birmingham, at 2 p.m. It is intended that membership shall be open in the first instance, subject to approval of the Council of the Association, to all graduates in pure and applied science normally resident in Great Britain who have been associated with atomic energy projects in Britain, Canada or the United States, and in special cases to such other persons as the Council may from time to time admit. Anyone eligible for membership who would like further information is asked to communicate with the Secretary, Atomic Scientists' Association, University College, Gower Street, London, W.C.1.

Bulletin of the Atomic Scientists of Chicago

SEVERAL issues of the *Bulletin of the Atomic Scientists of Chicago* have now appeared. The bulletin, a printed leaflet of several pages, is published twice monthly and is available free on request. The activities of the various committees of Senate and Congress investigating atomic energy and the evidence presented to these committees are regularly reported in detail. Articles by well-known scientific men, such as Prof. Marshak, the economist, Prof. Urey, the chemist, and Profs. Ridenour and Teller, the physicists, have appeared in recent issues. In addition, the bulletin has been producing a series of articles on "Control Problems". The first five articles of the series have dealt with a general survey of the problem, the control of uranium mining, the control of a gaseous diffusion plant, aerial survey as an aid in mining control, and the control of mineral production. The editors of the bulletin are H. H. Goldsmith and E. Rabinowitch, and the address 1126 East 59th Street, Chicago 37, Illinois.

Arthur Stanley Eddington Memorial Lectureship

AN influential committee of leading men of many branches of science has issued an appeal for the foundation of an Arthur Stanley Eddington Memorial Lectureship, providing for periodical lectures on some aspects of contemporary scientific thought considered in its bearings on the philosophy of religion or on ethics, to be delivered in Cambridge or elsewhere. Sir Arthur Eddington, who died at the end of 1944, was one of the few recent scientific thinkers of the

first rank who have attempted to think out a view of the world which would do justice to all fields of knowledge and experience. His reputation as an astronomer and mathematician were international; he combined great powers of scientific and philosophical analysis with a deep religious faith and a practical mysticism which found expression in his active and life-long membership of the Society of Friends, and in his intense concern for the ways of peace. These qualities, together with his humility and simplicity, made it possible for him to understand the needs and perplexities of ordinary thinking men; and the simple and vivid style in which he lectured and wrote enabled him to communicate to non-specialists an appreciation of the essence of scientific thought as well as of some of the most recondite advances in physics and astronomy. What makes Eddington such an important figure in contemporary thought is not that the synoptic view of the world which he put forward is necessarily the one which will ultimately be found to be nearest the truth, but that he saw that a synoptic view was necessary, and that we cannot be content with a departmentalization of knowledge in which science appears to be disconnected from the other fields of human inquiry—philosophical and religious.

To establish the proposed Lectureship, for the administration of which the Royal Society, Trinity College, Cambridge, and the Society of Friends have agreed to appoint trustees, will require a capital sum of about £2,500. Subscriptions may be sent to Barclay's Bank, Ltd., Cambridge, for the credit of "The Arthur Stanley Eddington Memorial Lectureship" account, or to the honorary secretary of the appeal committee, Dr. W. H. Thorpe, Jesus College, Cambridge, or to the honorary treasurer, Mr. Howard Diamond, 45 St. Barnabas Road, Cambridge.

Gift for Pharmacology in the University of London

Under the will of the late Sir Henry Wellcome, all the profits of the Wellcome Foundation are allocated to trustees to finance research in human and veterinary medicine and allied subjects. Thus the profits made by the sale of medicinal chemical and biological products all go to the further development of medical science for the benefit of the whole community. The close association between the source of the funds and the charitable object to which they are applied should make for a unity in the direction of research effort, and we may hope that the Wellcome funds will achieve even greater results in medical research than the other great charitable endowments already in existence from other industries. The trustees have now made a most generous gift of £74,000 to the University of London to endow the chair of pharmacology at the College of the Pharmaceutical Society and to contribute towards the cost of the research work.

This Pharmacological Department was instituted in 1926 under Prof. J. H. Burn, who later went to the chair at the University of Oxford and was followed by Prof. J. H. Gaddum, now professor of pharmacology at Edinburgh; Prof. G. A. H. Buttle was appointed last year in succession to Prof. Gaddum. The work of the Department consists of research into the mode of action and standardization of therapeutic substances and their application in medicine. A great deal of the original research which has led to the biological standardization of drugs including hormones and vitamins has been done in these laboratories. Recently Dr. Marthe Vogt has discovered that the injection of adrenaline into the animal will cause a secretion of the hormone of the suprarenal cortex; work is now being done to determine the conditions governing the output of this hormone. Chemotherapeutic experiments have been started and it is hoped to investigate the mode of action of anti-bacterial and anti-malarial drugs, and thereby to contribute to the production of more effective substances and to provide further data regarding their uses in therapeutics. The generous gift of the Wellcome trustees will be a considerable help in providing for the cost of the work.

Research into the Common Cold

A Common Cold Research Unit is being established by the Medical Research Council and Ministry of Health, and will start work in July. It will be housed at the Harvard Hospital, near Salisbury, which was built and equipped in 1941, and given to the Ministry of Health by Harvard University and the American Red Cross as a place for research into communicable diseases. The problem of the common cold is a particularly complex one, made more difficult because, apart from chimpanzees, which are unsatisfactory for experimental purposes, it has not yet proved possible to study it in animals. Progress towards the discovery of effective means of preventing a number of other diseases has not been made until some way of observing the disease in animals became available. For example, an effective vaccine against yellow fever became possible only when rhesus monkeys, and later mice, were found to be susceptible to the virus of the disease. Similarly, not until it was discovered that ferrets were susceptible to influenza virus was any progress made with the study of influenza. Therefore, the first objective on the present investigations into the common cold is to find a susceptible animal or, better still, some other laboratory technique which will permit a scientific approach to the problem.

As a check on their laboratory studies, workers at the National Institute of Medical Research will, at least for the time being, require to test on human volunteers the cold-producing activities of materials they are studying. These tests, due to start in July, will be carried out at the Harvard Hospital. The volunteers will for the time being be drawn from men and women students at the universities. First they will be isolated until it is certain that they are free from infection. Then, after a few days quarantine, their noses will be sprayed with material to see whether or not it contains a virus. While these observations are being made—for a period of ten to fourteen days in all—the volunteers will be out of contact with the outside world and each other except that, to obviate the boredom of solitary confinement, they will normally live together in pairs. Isolation will not involve complete loss of freedom, for the volunteers will be allowed to move about the countryside around the hospital, provided they avoid all human contacts, and will live in restful and comfortable holiday conditions. Volunteers are already being recruited from among university students. If more are needed later, an appeal will be made through suitable organisations. Volunteers must be carefully selected because special qualities are needed and an exact discipline must be maintained. For this reason the Medical Research Council is selecting its own recruits, and applications from the general public cannot be entertained. Progress towards the solution of the

many problems is likely to be slow, and it would be unwise to expect any spectacular advance, at any rate in the near future.

Mechanization of Milk Production

FOLLOWING a recommendation made by the Agricultural Machinery Development Board, the Ministry of Agriculture, after consultation with the Ministry of Food, has made arrangements for two members of the staff of the National Institute for Research in Dairying, namely, Mr. H. S. Hall, head of the Dairy Engineering Section, and Mr. A. Rowlands, bacteriologist, to visit the principal milk-producing areas of the United States and Canada; they will also visit State colleges and universities. The main objects of the mission will be to examine the mechanization of milk production and handling with particular reference to cow-shed practice, machine milking, the design of milk equipment, methods of cooling and sterilizing, and the effects on the bacteriological quality of milk; and to study the current research work being undertaken in this field.

University of Reading

THE Council of the University of Reading has accepted the resignation of the vice-chancellor, Sir Franklin Sibly, on medical advice, as from September 29. Dr. E. A. Guggenheim, of the Imperial College of Science and Technology, London, has been appointed to the chair of chemistry in succession to Prof. H. Bassett; and Prof. R. W. Ditchburn, Erasmus Smith's professor of natural and experimental philosophy, Trinity College, Dublin, to the chair of physics in succession to Prof. J. A. Crowther.

University of London Appointments

PROF. H. DINGLE, professor of natural philosophy at the Imperial College of Science and Technology since May 1938, has been appointed to the University chair of the history and philosophy of science tenable at University College as from October.

Prof. Willis Jackson, professor of electrotechnics at the University of Manchester, has been appointed to the University chair of electrical engineering tenable at the Imperial College of Science and Technology as from October 1.

Dr. J. N. Davidson, member of the scientific staff of the Medical Research Council at the Institute for Medical Research, Hampstead, has been appointed to the chair of biochemistry tenable at St. Thomas's Hospital Medical School as from April 1.

Prof. A. J. E. Cave, secretary of the Anatomical Society, has been appointed to the University chair of anatomy tenable at St. Bartholomew's Hospital Medical College as from May 1.

Dr. O. A. Saunders, Clothworkers' reader in applied thermodynamics at the Imperial College of Science and Technology since 1937, has been appointed to the University chair of mechanical engineering tenable at the Imperial College as from October 1.

The title of professor of medical protozoology in the University of London has been conferred on Dr. H. E. Shortt, in respect of the post now held by him at the London School of Hygiene and Tropical Medicine; the title of professor of embryology in the University of London has been conferred on Dr. G. R. de Beer, in respect of the post now held by him at University College.

Announcements

ON April 11, the Council of the Royal Society nominated Lord Keynes for election to the fellowship under Statute XII, which empowers the Society to elect each year not more than one person of special eminence. Owing to the death of Lord Keynes, the nomination could not be balloted for at an ordinary meeting of the fellows. The President, Council and fellows of the Royal Society make this announcement in order that the esteem in which Lord Keynes was held by the Society should be generally known.

SIR HENRY TIZARD, president of Magdalen College, Oxford, has been awarded a Franklin Gold Medal. This Medal is awarded annually to those workers in physical science or technology, without regard to country, whose efforts, in the opinion of the Franklin Institute, have done most to advance a knowledge of physical science or its applications. The award to Sir Henry is "in recognition of his outstanding contributions, which have advanced the science of aeronautics in the fields of full scale flight test procedure; internal combustion engines, relating to fuel economy; and for his leadership in aeronautical research and development which, in part, involved the development of special devices for air offensive operations and for defence against an attack". Sir Henry has also been elected to honorary membership of the Franklin Institute.

THE first annual Ernest Jones Lecture of the British Psycho-Analytical Society will be delivered by Prof. E. D. Adrian at the Royal Society of Medicine on June 19 at 8 p.m. Prof. Adrian will speak on "The Physical and Mental Sources of Behaviour".

THE Board of Governors of the College of Aeronautics has appointed Prof. W. J. Duncan, of the Royal Aircraft Establishment, Farnborough, and previously Wakefield professor at the University College of Hull, to be professor of aerodynamics; and Mr. R. L. Lickley, chief project engineer, Hawker Aircraft Co., to be professor of aircraft design.

BRIGADIER R. A. BAGNOLD has been appointed research director in the United Kingdom for the Shell Group of oil companies. Brigadier Bagnold, who was elected a fellow of the Royal Society in 1944, is well known for his work on hydraulics, the physics of desert sands and beach formation. After graduating at Cambridge he spent many years in the Royal Engineers and organised and led numerous explorations in the Libyan Desert. During the recent War he raised and commanded the Long-Range Desert Group in the Middle East. He was a member of the Science Commission of the Conference of Allied Ministers of Education.

THE Medical Committee of the Scientific Film Association is offering reciprocal co-operation in the production of medical films, in order to avoid overlapping. If at the inception of a plan to make a new medical film the Committee is informed, it will do its best to inform the intending producer of existing films on the subject; and where two or more organisations or persons more or less simultaneously disclose to the Committee the same or overlapping subjects for a medical film, the two parties concerned will be informed that others are in the field, but names will not be disclosed. Offers of co-operation should be made to the Hon. Secretary, Medical Committee, Scientific Film Association, c/o Royal Society of Medicine, 1 Wimpole Street, London, W.1.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Responses of Seedlings to Animal Embryonal Extracts

STIMULATION of growth of animal tissues by embryonal extracts of animals is a well-established fact since its discovery by Carnot[1]. The influence of extracts of plant embryos on the growth of higher plants is still a subject of controversy.

Hungarian workers have extracted from the hearts of embryos a substance which, they claim, stimulates the growth of the myoblasts of the heart by accelerating the rhythm of cell proliferation, both mitotic and amitotic[2]. The substance is called 'Corhormone' and has found application in human therapeutics. This action is claimed to be specific: the embryonal extract alone, after the 'hormone' has been isolated, has no such effects.

I have tried to ascertain the effects of both 'Corhormone' itself and the embryonal extract ('M.Gy.23') containing no 'hormone' (both kindly given by the Hungarian Pharmaceutical Products Co.) on seedlings of radish, *Raphanus sativus* var. *Saza*.

Thirty-eight seeds in each series were germinated in Petri dishes, lined with filter paper, in a 1 : 20 solution of 'Corhormone' or in the embryonal extract of the same concentration. Nutrient solution was added on the fourth day of the experiment, and the treatment with 'Corhormone' and the embryonal extract was repeated on the second and seventh day of the experiment. Tap water was used as control. The accompanying table shows some of the results obtained.

Treatment	Height (mm.)	Coefficient of area of leaves	Weight of aerial parts per plant (mgm.)	Weight of stems per mm. length (mgm.)	Length of roots (mm.)	Weight of roots per plant (mgm.)	Weight of roots per mm. length (mgm.)
'Corhormone'	58	143	99	1·19	111	24	0·22
Embryo extract	49	154	76	1·65	94	38	0·39
Control	43	79	57	1·23	82	23	0·28

Increases in the size of the leaves were brought about by both 'Corhormone' and the embryonal extract.

There was also a gain in the weight of the aerial parts in the treated plants, but the difference in favour of 'Corhormone' is almost as marked when compared with the embryonal extract as between this last and the controls. This is due to the hypertrophy and increased succulence of the leaves of the plants treated with 'Corhormone': for as can be seen when the weights per mm. length of the stems of the two series of treated plants are compared, it was the stems of the plants treated with 'extract' which were hypertrophied. Similar remarks hold for the thickening of the roots.

Luxuriant growth and an increased number of root-hairs and of secondary roots on the plants treated with 'Corhormone' were also observed, as compared with both the plants treated with 'extract' and the controls.

Preliminary cytological examination of the leaves of the plants treated with 'Corhormone' showed islands of large stomata among others of the size of the controls, thus indicating myxoploid tissue. The stomata of 'extract'-treated plants were of normal size.

These observations suggest *inter alia*:

1. Confirmation that the transverse reactions of plants and their sequels, such as we have described as the 'alarm signals' or syndromes of phytocarcinomata and polyploidy[3], are in a great measure independent of the chemical constitution of the substance administered[4], similar results having been obtained by carcinogenic and polyploidizing agents of widely different chemical structure[5-6].

2. That, in spite of certain similarities between the effects of 'Corhormone' and the embryonal extract, other effects on plants seem to justify a certain specificity of action of 'Corhormone', as claimed for its effects in the animal organism.

3. The sensitiveness of the seedlings in giving different responses to the two substances is a new argument in favour of the use of plants as pharmacological test-objects, as advocated by Macht and Krantz[7] for another heart-active substance (in digitalis assay).

It is not yet known whether 'Corhormone' is to be considered as a true hormone or rather as a nutrient like the trephones[8]. The final interpretation of these observations must depend upon further work.

LASZLO J. HAVAS

Hungarian College of Horticulture,
Institute of Special Fruit Growing,
Budapest.
Jan. 20.

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Number of Tentacles in *Hydra vulgaris* as a Genetic Character

THE number of tentacles in *Hydra vulgaris* Pallas varies from three to nine. The frequency distribution in 869 individuals is

Number of tentacles	3	4	5	6	7	8	9
Number of hydra	1	2	61	646	132	24	3

From this, though any definite conclusion is risky, it is difficult to see that the number of tentacles in *Hydra* is the result of any single environmental factor as size or age. A normal curve of number of tentacles will be in general the distribution under environmental variations.

The number of tentacles in the adult and that in the buds, however, do not always correspond. A *Hydra* with 6 tentacles may carry buds with 4, 5, 6, 7 or 8 tentacles. The relationship between the number of tentacles in the adult and that in the buds is shown in the accompanying table:

Number of tentacles in the adult	Number of tentacles in the buds: *1st bud*	*2nd bud*	*3rd bud*	Number of cases
9	7	7	9	1
9	8			1
9	7	8		1
9	7			2
8	8	6		1
8	7	7		1
8	7			2
8	6			5
8	6	6		2
7	8			1
7	7			4
7	7	7	5	1
7	7	8		1
7	7	6		3
7	6			21
7	6	6		9
7	6	5		1
6	8			2
6	7	7	5	1
6	7			11
6	7	6		4
6	6	7		12
6	6	6		39
6	6			90
6	6	5		4
6	5			5
6	4			2
5	6	7		2
5	6	6		5
5	6			2
5	6	5		1
5	5			1
5	4			1

From the above table, two points can be seen: (1) That the number of tentacles in the buds is never more than the number of tentacles in the adult plus 2, and is never less than the number of tentacles in the adult minus 2; or in other words, if the number of tentacles in the adult is a, the number of tentacles in the buds lies within the range of $a + 2$ and $a - 2$; (2) That the number of tentacles in buds of the adults which carry more than 6 tentacles tends to be less than the number in the adults, and the number of tentacles in buds of the adults which carry less than 6 tentacles tends to be more than the number in the adults. For example, if a *Hydra* has 8 tentacles, its buds tend to have less than 8 tentacles, or if a *Hydra* has 5 tentacles its buds tend to have more than 5 tentacles. This is according to the law of filial regression.

The filial generations of the *Hydra* by budding have been individually recorded. Though the results at present have not yet reached the stage for analysis, there are a few cases worth mentioning. There are two *Hydra* with 6 tentacles, and one *Hydra* with 7 tentacles which have all bred true for three generations. Although these cases might simply represent coincidences among a vast number of cases, it is also possible that they are really pure lines which breed true. Should the latter assumption be true, which can be confirmed with further breeding, then there is promise for future research in the crossing of these pure lines.

The arrangement of the tentacles around the hypostome is always in radial symmetry whatever the number. The determination of the number of the tentacles in the buds is always very early in the life-history, and is independent of either the size of the adult or the size of the bud itself. A small bud may have as many as 8 or 9 tentacles while a large one may have only 4 or 5 tentacles. Though this fact does not necessarily prove that the number of tentacles in *Hydra* is a genetic character, it is difficult to explain on the hypothesis of environmental variations why the number of tentacles does not correspond with the size of the buds.

We do not wish to discuss at this time the mode of inheritance in the number of tentacles. But one thing seems to be clear: the mode of inheritance in budding will be different from the mode of inheritance in sexual generations. Some new hypothesis may be necessary to explain why the number of tentacles in the adult does not correspond with the number of tentacles in the buds.

T. T. LIU
JOSEPH T. CHANG

Department of Biology,
Yenching University.

Transmission of the Carbon Dioxide Susceptibility of *Drosophila* by Grafting

THE hereditary carbon dioxide susceptibility in *Drosophila* was discovered and first investigated by L'Héritier and Teissier[1]. This physiological character behaves like a hereditary unit and its transmission in the crosses follows definite, but non-Mendelian, rules. It exhibits no linkage with any chromosome and is carried in a different way by the spermatozoon and the ovum.

On the other hand, experiments of different types failed to show any possibility of conveying the susceptibility to resistant individuals by mere contagion. Resistant larvæ fed with mashed susceptible flies, as well as pupæ or imagines injected with endolymph from susceptible individuals, do not become susceptible. But when resistant flies are mated simultaneously to resistant and susceptible males, a few susceptible flies are found among the progeny of the resistant males. This fact is due, apparently, to the polyspermy usual in *Drosophila*, the susceptibility being carried into the ovum by a supernumerary spermatozoon.

L'Héritier and Teissier therefore concluded that the susceptibility was due to a self-reproducing agent, located in the cytoplasm of the germinal cells. Its precise nature—plasmagene or virus—remained unknown: but, if the susceptibility was the manifestation of a kind of infectious disease, its transmission by contagion from one individual to another was at least an improbable event.

We thought it would be interesting to apply to the problem of the nature of this agent Ephrussi and Beadle's method of transplantation, in order to ascertain whether the susceptibility could not be transmitted to an ovary of a resistant strain, transplanted into a susceptible host. Ovaries from wild-type resistant larvæ were transplanted into 'ebony'-susceptible hosts. The adult flies were, afterwards, mated with 'ebony'-resistant males. If the transplanted ovary succeeds in joining up with the genital ducts and becomes functional, two types of progeny are produced: ebony and phenotypically wild-type flies, the later coming from the transplanted ovary.

We have, up to date, succeeded in getting three females with a functional transplanted ovary. They were allowed to lay eggs for some days, then tested for the susceptibility. They were all found susceptible, as well as all their ebony offspring. Moreover, in each case, part of the wild-type progeny was also susceptible. In all, 48 susceptible wild-type flies were found. Among them 7 males and 7 females, issue from the first successful transplantation, were mated before the test with resistant individuals, and their progeny raised. None of the males was able to transmit the susceptibility, but all the females transmitted it to the whole or to a part of their offspring.

In a recent paper[2], Kalmus and Mitchison recorded quite different results of similar transplantation experiments. The susceptibility was not transferred to any of the ova of the transplanted ovaries and, moreover, among the progenies of the host ovaries many resistant flies were found. We do not know whether this disagreement is a mere matter of chance, the number of successful transplantations being very small in both cases, or due to some difference in the experimental conditions.

The agent responsible for the carbon dioxide susceptibility, normally conveyed by the gametes like a hereditary determinant, can also be transmitted from the host to the gametes of a grafted ovary. Whether, in the present stage of the investigations, it should be described as a plasmagene or as a virus remains, to a large extent, a matter of definition.

We are indebted to Prof. B. Ephrussi and Mr. L. Goldstein for technical help and advice in this work.

PH. L'HERITIER
F. HUGON DE SCOEUX

Laboratoire de Génétique,
Faculté des Sciences,
Paris.

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Digestion of Animals by Lamellibranchs

IN his communication in *Nature* of April 13, Prof. K. Mansour[1] has raised a matter of great interest to me, and I look forward to seeing the papers in which his complete results will appear. It is gratifying to know that one of his wide experience in the field of invertebrate digestion has turned his attention to the Lamellibranchia.

In his observations that animals may pass into the gut of lamellibranchs and there show evidence of being digested extracellularly, Prof. Mansour has been anticipated by Nelson[2]. On occasion he found in the stomachs of *Ostrea edulis* and *O. virginica* living and disintegrating animals, notably the free-living nematode, *Chromadora* sp. Nelson suggested the presence of a protease in the style but such has never been identified, my own findings on *Ostrea*[3] being fully confirmed by those of Fox *et al.*[4] on *Mytilus*. Prof. Mansour makes the alternative suggestion that the digestive diverticula secrete protease. Histologically there is no evidence for this. Here I may cite personal observations on many species[2-5] and those of Vonk[6] on *Ostrea* and Graham[7] on *Ensis*. It is not surprising to learn that in *Unio* injected chlorophyll solutions later appear in the cells of the diverticula. These must elaborate their intracellular digestive enzymes and obtain the necessary material from the blood. Subsequent appearance in the lumen of the gut of globules containing chlorophyll is to be expected. The indigestible residue after intracellular digestion is regularly passed from the cells of the diverticula into the gut. This has also been described by Graham[8] in the gastropod, *Patella*, where the diverticula digest intracellularly as they do in lamellibranchs.

The suggested presence of extracellular protease and lipase in the gut raises the question of the phagocytic blood cells which pass in great numbers into the lumen. Of their powers of ingestion and digestion I have given abundant evidence[3], and Takatsuki[9], while working under my direction, extended and confirmed these observations and demonstrated the presence of these enzymes in the phagocytes. Even after filtration the stomach fluids usually exhibit some proteolytic and lipolytic action[3,7], because some phagocytes inevitably cytolize. But Vonk[6], Graham[7] and Fox *et al.*[4] all agree in considering that extracellular protease and lipase are absent from the gut of lamellibranchs. There is also the question of the style; being of protein, it is difficult to see how it could exist in the presence of extracellular proteases[10]. No style-bearing gastropod (where phagocytes are absent) has been shown to possess extracellular protease. In the protobranch Lamellibranchia, I have shown[11] that phagocytes are absent from the gut; but unfortunately these animals are too small to provide adequate samples of uncontaminated stomach fluids. But it is noteworthy that the absence of phagocytes is accompanied, in the Nuculanidæ, by the presence of additional wide diverticula in which complete diatoms may be ingested. In herbivorous prosobranch Gastropoda with essentially the same type of diverticula as lamellibranchs, for example *Patella*[8] and *Pterocera*[12], there are no phagocytes and no extracellular protease has been found. Even in the carnivorous nudibranch, *Jorunna*, Millot[13] found no extracellular protease, although this is usually present in carnivores.

I would suggest an alternative explanation for the presence of semi-digested animal remains observed by Nelson and by Mansour. After feeding *Ostrea edulis* with an emulsion of olive oil stained red with nile blue sulphate, I later found[3] in the stomach vast numbers of phagocytes most of them with ingested oil now stained blue owing to conversion to fatty acids. In certain cases many phagocytes had collected around droplets of oil which had turned blue; all droplets not so surrounded retained the red stain. It would appear that phagocytes may burst (one can scarcely visualize them as secreting) and their contained enzymes be liberated. What may occur with fats may occur with proteins. Clearly vast numbers of phagocytes are needed to produce this effect, but the supply is available. Possibly the presence of animals in the stomach stimulates migration of phagocytes into the lumen. The digestion of animals in the gut of lamellibranchs is not invariable; many workers have observed living animals in the fæces, notably Sherwood (quoted by Savage[14]) and Nelson[15]. I remain convinced that lamellibranchs, other than septibranchs[16], are specialized herbivores; the presence of any significant quantity of animal matter in the gut is rare as shown by the exhaustive analyses of stomach contents in *Ostrea* and *Mytilus* by Savage[14] and by Fox *et al.*[4]. It does appear that under certain conditions the gills and palps may pass into the mouth relatively large numbers of animals. It is not impossible that there is a pronounced reaction to their presence by the migration of phagocytes into the gut lumen, as much, perhaps, for protection of the gut as for nutrition.

In conclusion, I would point out that in my work on *Tridacna*[17] I was at pains to point out that, although zooxanthellæ are certainly consumed in great numbers, the animal retains intact the power of normal feeding and digestion.

C. M. YONGE

Department of Zoology,
University,
Glasgow.
May 3.

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Musa Fehi, the Indigenous Banana of Fiji

DURING a recent visit to the Western Pacific, I was able to examine in Viti Levu, Fiji, the indigenous edible banana known as 'Soaqa'. Its vegetative and floral characters conform to the description of *Musa Fehi* Bertero *ex* Vieill[1], with which *M. Seemanni* F. v. Muell. is probably conspecific. Specimens were also collected from Malaita, B.S.I.P. Conflicting accounts of the seminal fertility of this species appear in the literature[2,3,4], and are typified by Baker's statement[5] that it is "seedless at the low levels but bearing seeds at an altitude of 3000–6000 ft.". In three inflorescences which I examined, successive hands (clusters of flowers subtended by a bract) were as follows:

Origin	Age	Flowers per hand: Female	Transitional	Male
Viti Levu	Fairly mature	7 5 3 2 2 2 2 2 1	1	Nil
Malaita	Fairly mature	2 8 7 5 4 3 3 3 2	2	Nil
Viti Levu	Within pseudo-stem	8 8 7 6 5 3 3 2	1	3 2 2 2 1 1 1 1

The rachis distal to the fruits was withered in each of the fairly mature bunches, but its remnant showed the scars of a few bracts. In the young bunch, only the first four hands of male flowers (a total of nine flowers) were morphologically fairly regular, the remainder being contorted. Pollen was very sparse; many grains were empty and those with contents were variable in size. Thus the male phase is transitory and the anthers are virtually sterile.

M. Fehi is the only indigenous banana of Fiji. Introduced varieties cultivated for export are mainly Veimama, Cavendish, Gros Michel

and Lady's Finger, all of which are triploids ($3x = 33$) and highly sterile. Clearly, with a virtually complete absence of pollen of *Musa*, there seems no likelihood of seed occurring in *M. Fehi* in Fiji.

A further observation supports this view, for preparations of root-tips showed that *M. Fehi* has $2x = 20$ chromosomes, belonging to that sub-group of the genus with $x = 10$. Evidently parthenocarpy has been evolved in this sub-group in a manner directly comparable with that found in edible diploids of the sub-group $x = 11$[6]. It is a fair inference that the total sterility of *M. Fehi* recorded here results from female sterility associated with parthenocarpy and sterility consequent upon structural hybridity of the chromosomes, affecting both sexes alike.

Viable seeds are occasionally set by established edible diploids of the $x = 11$ sub-group, with pollen from seeded (non-parthenocarpic) diploid relatives[6]. By analogy, *M. Fehi* might be expected to set seeds rarely, given a source of viable pollen. It is of interest, therefore, to record the presence in Malaita of a fertile-seeded diploid with $2x = 20$ chromosomes, growing adjacent to *M. Fehi* and vegetatively indistinguishable from it. The bunches of the seeded species, however, were borne sub-horizontally and contained about twenty hands, each with about twenty-eight fruits. Being fully seeded, about 10 cm. in length (inclusive of a petiole about 4·5 cm. long) and 2·5 cm. in diameter, they were quite distinct from the sub-sessile fruits of *M. Fehi*, similar in length but about 5 cm. in diameter and filled with edible pulp.

The conflicting accounts of the seminal fertility of *M. Fehi* seem to result from a failure to distinguish between seeded and edible types. It may be inferred that the situation resembles that in *M. acuminata* Colla ($2x = 22$), of which there are both parthenocarpic and seeded types. An intensive search in the islands of the Western Pacific would probably reveal seeded types of *M. Fehi*, that is, the sexual progenitors of the edible types.

I am indebted to Prof. E. E. Cheesman for access to transcripts of the pertinent literature.

K. S. Dodds

Department of Botany,
Imperial College of Tropical Agriculture,
Trinidad. April 2.

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Changes in the Contents of Acetylcholine in Nervous Tissue under the Influence of Constant Current

Up to the present, little is known of the chemical changes that take place in nerve and muscle tissue under the influence of constant current. The existence of such changes has been pointed out by Pravdicz-Neminsky[1], Robbins and Wilhelm[2], Scheminzky and Köllensberger[3] and Muralt[4], but their physiological significance is still unestablished.

We have undertaken a detailed study of the relationship between the phenomena of electrotonus and the production and breakdown of acetylcholine with the view of determining the role of this substance in the origin and development of the electrotonic changes of excitability. Our investigation was based on the premise that the physical and physico-chemical events arising in nervous tissue during excitation are accompanied by chemical changes and in particular by the formation and destruction of acetylcholine. We regard the production of acetylcholine in nervous centres and fibres as an after-effect of excitation, responsible for the onset of the changes of excitability following in the wake of the nerve impulse.

The only experimental work hitherto dealing with the influence of electrotonus upon the distribution of acetylcholine was that of Muralt[4]. Muralt has established that catelectrotonus increases and anelectrotonus lowers the contents of acetylcholine in the nerve, and explains this fact as a consequence of the increased production of acetylcholine in the nerve when its excitability is high.

Our investigations in collaboration with N. A. Raspopova and I. G. Kovyrev show that polarization of the brain of frogs and of the cerebral cortex of dogs and cats leads to the increase of acetylcholine in the region of the cathode, and to its decrease in the region of the anode as compared to its contents in control (unpolarized) parts of the brain. The technique of our experiments was as follows: unpolarizable du Bois Reymond electrodes connected with an accumulator were applied to the bared surface of the brain. Polarization was performed during 10 min. with a constant current of 4–10 mA., after which pieces of the brain were taken from under the electrodes, as well as a piece serving for control from a point not subjected to polarization. The three pieces of brain were triturated with a small quantity of eserinized Ringer saline, the emulsions were centrifuged and their contents of acetylcholine determined on the dorsal muscle of the leech.

Emulsions prepared from pieces of the brain taken at the cathode invariably gave a considerably greater contraction of the muscle than those prepared from pieces taken at the anode and control pieces; emulsions prepared from pieces taken at the anode gave either a smaller contraction than those prepared from control pieces or one of the same volume.

The anode, when applied to the same point immediately after the cathode, causes a diminution of the contents of acetylcholine at this point.

Polarization of nerve fibres of the frog, dog and cat produces the same changes in the acetylcholine content at the poles. In these experiments also, emulsions prepared from polarized and unpolarized parts of nerve-trunks were tested on the dorsal muscle of the leech. The duration of polarization was 1–15 min. with a constant current of 1–8 mA. In some experiments the polarization was stopped after immersing the nerve in liquid air.

Emulsions prepared from the part of the nerve subjected to the action of the cathode produced a much stronger contraction of the muscle than those prepared from the anode or the control parts. The anodal part gave an emulsion which produced a smaller contraction than the emulsion prepared from a control piece of the nerve.

Hence the cathode produces an increase in the acetylcholine content of nervous tissue, while the anode produces a decrease. A theoretical discussion of these data will be given elsewhere.

Eug. B. Babsky

Laboratory of Physiology,
State Pedagogical Institute,
Moscow.

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Porphyrin Formation by Yeast

In a recent communication[1] a method was described by which increased yields of coproporphyrin could be obtained from yeast preparations. To secure information on the mode of production of this pigment, we examined the possibility that breakdown of preformed chromoproteins containing protoporphyrin as a component of the prosthetic group could be responsible. Such pigments occurring in yeast are cytochrome-*c*, catalase and peroxidase. Although the concentration of these proteins is low, it is possible that in the yeast preparations they are synthesized continuously and then rapidly degraded to porphyrin, thus reaching dynamic equilibrium under these special conditions. To test this supposition, each individual protein was added to the standard yeast preparation and the subsequent porphyrin production examined.

Cytochrome-*c* prepared from heart muscle by the method of Keilin and Hartree[2] was added in concentrated aqueous solution. The results showed that cytochrome-*c* was decomposed without influence upon the yield of porphyrin. To ensure that the cytochrome-*c* came into contact with intracellular enzymes the experiment was repeated with ruptured yeast cells, but these cells formed little porphyrin and cytochrome was without effect. The changes in cytochrome-*c* were followed by centrifuging weighed samples of the preparation, and determining the pigment as ferrocytochrome-*c*, after treatment with a normal solution of caustic soda and solid sodium hydrosulphite.

Peroxidase prepared from horse-radish by the method of Keilin and Mann[3] was obtained only in small yield, so that no information could be obtained on the fate of the enzyme except that its presence did not augment porphyrin production.

Catalase from ox-liver (Sumner and Dounce[4]) was similarly ineffective. The enzyme was decomposed from the beginning and it is interesting to observe that its degradation proceeded most rapidly in yeast alone where no porphyrin could be detected (capability, Kat. f. 0 hours, 1,460: 96 hours, 237) whereas breakdown was retarded in porphyrinogenic preparations containing ammonium carbonate and glucose (Kat. f. 0 hours, 1,016: 96 hours, 426).

These observations support the view that if these chromoproteins are being produced continuously by the activity of the yeast cells, they will not be catabolized to coproporphyrin, and we must consider more fully a possible synthesis from simple compounds. First, it was thought important to discover whether coproporphyrin is an irreversible end-product or an intermediate which can be further metabolized. Additional coproporphyrin, extracted from yeast and therefore deemed most appropriate for this study, was put into yeast preparations and the response examined after varying intervals of time. It was at once evident that the yeast cells were able to metabolize additional porphyrin almost as effectively after 96 hours as at the beginning of the experiment. Occasional strains of yeast could not remove excess porphyrin. When excessive amounts of porphyrin were employed, the yeast reacted to use up still more pigment. These findings suggest that coproporphyrin is being formed continuously as an intermediate metabolite, but for some reason its rate of formation and utilization are slightly out of harmony. The interesting observations of Conway and Breen[5] on the rapid growth of 'ammonia' yeast may have an important bearing on the accumulation of porphyrin in yeast, and we are studying the pigment yield in relation to the rate of cell division.

We should like to thank the Sir Halley Stewart Trustees for their continued support of these investigations.

J. E. Kench
(Sir Halley Stewart Fellow)
J. F. Wilkinson

Department of Clinical Investigations and Research,
Manchester Royal Infirmary.

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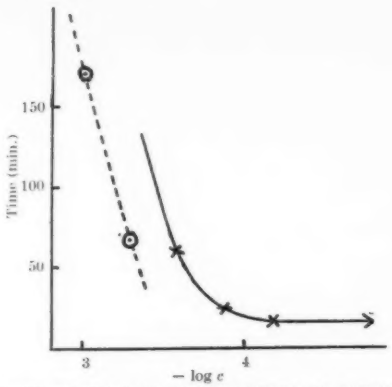
Inhibitory Effect of Tetranitromethane on the Diphtheria Toxin–Antitoxin Precipitin Reaction

We have investigated[1] the influence of tetranitromethane on the precipitin reaction between diphtheria toxin and the corresponding horse antiserum. When present in the antibody solution before mixing the serological components, tetranitromethane has a remarkable inhibitory effect on the flocculation, even at very low concentrations. The graph shows the influence of different concentrations of tetranitromethane on the flocculation time (concentrations in mol./litre). When tetranitromethane is added to the antigen before mixing it with the antibody, the effect is very weak, and when it is added to the mixture of the serological components, the flocculation is normal. Tetranitro-



INFLUENCE OF DIFFERENT CONCENTRATIONS OF TETRANITROMETHANE ON THE FLOCCULATION TIME WHEN TETRANITROMETHANE IS ADDED TO SERUM

—×——×— maximal *tact*.
— — ○ — — shorter *tact*.

methane could easily be removed (by extraction with benzene and other methods) from its mixture with the toxin, but not from its mixture with the serum. Several facts indicate that tetranitromethane inhibits the specific combination of antigen with antibody, not the flocculation of the addition compound.

By adding tetranitromethane to the mixture of antigen and antibody at different times after mixing the latter, the velocity of the antigen–antibody reaction could be limited to less than 10 sec.

In different respects parallelism may be seen between the addition compounds of tetranitromethane with simple unsaturated substances (for example, oleic acid) and with proteins. In both cases the addition compounds are coloured and show a new absorption band at 350 mμ. Both reactions agree in the fact that equilibrium is reached in a measurable time (15–45 min.).

Tetranitromethane does not react with all proteins (only reversible reaction with diphtheria toxin, and no notable reaction with amylase). Hence it seems probable that tetranitromethane in some way interferes with the specific combining properties of the antibody. Probably there is no reaction at all with the specific groups of the toxin. The weak inhibition, when tetranitromethane is first added to the toxin, may be due to collisions and reactions between tetranitromethane and antibody molecules, when the latter is added to the tetranitromethane–toxin mixture.

Our experiments indicate that diphtheria toxin and its antibody combine by dissimilar groups, that is, contrary to what has been proposed by Jordan[2]. Attraction between dipoles and induced dipoles as well as resonance forces are possible at the combination.

Recent papers by Scheibe[3] and Sheppard[4] are of interest in this connexion. Through association, dye molecules attain new absorption bands. Furthermore, special resonance properties are made possible for large molecule aggregates.

Very few substances show any effect upon the precipitin reaction. It is, however, interesting to note that the physiologically active colchicine[5] and penicillin[6] exhibit a distinct, though weaker, retarding effect on the reaction in question.

LARS EHRENBERG
INGA FISCHER
NILS LÖFGREN

Institute of General and Organic Chemistry,
University of Stockholm.
March 21.

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Synergic Effect of Ascorbic Acid and Riboflavin on Penicillin *in vitro*

PENICILLIN is frequently given to patients who may be receiving vitamins at the same time, especially if there is a suspected or clinical deficiency in the patient. In the present investigation, the effect of some of the water-soluble vitamins on the potency of penicillin was tested *in vitro*.

Penicillin sodium was used diluted in distilled water to 2 or 4 Oxford units per c.c. The test organisms were *Staph. aureus*; 24-hr. broth culture was used. The titration was made either in broth or in the medium described by Fleming[1] and made up of 1 gm. peptone, 1 gm. glucose, 0·5 gm. sodium chloride, 1 c.c. Andrade's indicator and water to 100 c.c.

Strong solutions of vitamin B_1, riboflavin, nicotinic acid and vitamin C were freshly diluted from ampoules in sterile distilled water to the appropriate dilution. (The preparations used were: vitamin B_1 as 'Viberyl' (Solex, N.Y.) (thiamine hydrochloride containing 0·50 per cent chlorobutanol), riboflavin in the form of 'Beflavin' (Roche) (the ampoule is prepared from 5 mgm. lactoflavin, 80 mgm. sodium-2-oxy-4-methoxy-benzoate, 5 mgm. monosodium phosphate, with 1 c.c. distilled water), nicotinic acid as sodium salt ('Pelonin', Glaxo) and vitamin C as 'Redoxon' (Roche, synthetic *l*-ascorbic acid). All these vitamin and penicillin solutions were at about *p*H 7 and did not affect Andrade's indicator in the peptone medium, except vitamin B_1 solution which was acidic in reaction, having *p*H 4 when diluted in water and *p*H 5 when diluted in phosphate buffer.

Two dilution series were made at the same time for every titration: 1/2, 1/4, 1/8, etc., and 1/3, 1/6, 1/12, etc., in order to show smaller differences and to give more accurate results. Sodium penicillin 2 or 4 units per c.c. distilled water was serially diluted in broth or peptone medium in 1 c.c. volumes. Then 1 mgm. vitamin B_1 in 0·1 c.c. distilled water or phosphate buffer was added to each tube in one set, 1 mgm. nicotinic acid in 0·1 c.c. distilled water added to another set, 0·05 mgm. or 0·1 mgm. riboflavin in 0·1 c.c. distilled water added to the third set, 1 mgm. ascorbic acid in 0·1 c.c. distilled water added to the fourth set; penicillin only was added to the fifth set. Control tubes were set up. All titrations were made under the same conditions and incubated at 36° C. for 24 hours. The tubes containing riboflavin or ascorbic acid inhibited the organisms in a greater dilution of penicillin, while tubes containing both ascorbic acid and riboflavin, 1 mgm. and 0·05 mgm. respectively in 0·1 c.c. water, showed no greater effect.

Dilutions of 0·1 mgm. vitamin C in 0·1 c.c. and 0·002 mgm. riboflavin in 0·1 c.c. distilled water added to 1 c.c. volumes of penicillin dilutions in broth or peptone medium gave no definite effect; separate or combined.

On the other hand, when these vitamins were titrated against the same strain of *Staphylococcus* in broth and in peptone medium, vitamin B_1 and nicotinic acid showed no inhibitory effect at a concentration of 10 mgm. per c.c. Riboflavin inhibited totally the growth of *Staphylococcus* at a dilution of 1 in 4,000, while 0·05 mgm. per c.c. (1 in 20,000) did not.

Ascorbic acid, 10 mgm. per c.c., did not show any inhibition, while 100 mgm. per c.c. distilled water showed partial inhibition, a slight turbidity in the first tube (1 in 2) and heavy growth in the following tubes. Contradictory results were given by Ecker *et al.*[2], Spink *et al.*[3] and Angew *et al.*[4] and other workers[5] regarding the effect of ascorbic acid on the complement activity and the antibacterial power of blood. There is, however, evidence that infections, particularly those producing fever, cause a loss of vitamin C from the body and that it is needed in combating certain types of infection[6].

Riboflavin plays a part in cell respiration and is said to raise the resistance to infections[6]. Madinaveitia[7], during his work on the effect of riboflavin on some drugs, found that penicillin was not affected by riboflavin, but he failed to mention its synergism. The mechanism of the synergic action of riboflavin and ascorbic acid is not known; a big proportion of ascorbic acid in the solution is destroyed during incubation, and it seems that it produced an effect before destruction is complete.

The amount of the vitamins producing this synergism is high compared to the concentration generally present in the blood on systemic administration; but in the body many other mechanisms take part and positive findings are likely to be obtained. Further clinical study will show the value of these findings.

It is suggested that chemical combination of penicillin with either of these vitamins or similar substances may give rise to substances of higher activity or of wider range of activity against other organisms, as in the case of sulphonamides, where sulphapyridine, sulphathiazole, etc., were prepared after the discovery of the sulphanilamide.

MAHMOUD A. JALILI

Biochemistry Department,
Fouad I University,
Cairo.

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Changes in the Electrical Charge of Yeast Cells Treated with Sodium Fluoride

THE sign of the electrical charge of the yeast cell has been reported differently by various authors. Lüers and Geys[1], for example, have found washed and resting yeast to be positive. Hennig and Ay[2], on the other hand, have found it to be decidedly negative. If a sample shows a positive charge, this, according to the latter authors, must be due to the fact that some substance tending to alter the charge has been absorbed on the cell surface. Opinions also differ regarding the possibility of changing the sign. Thus Pfeiffer[3] obtained a change by varying the *p*H. Hennig and Ay[2], on the other hand, did not succeed in this respect.

My own researches on baker's yeast from the Swedish Yeast Factory Co. at Rotebro, Stockholm, have shown that the yeast plant is decidedly positive and remains so even with relatively large *p*H variations in the surrounding solution.

A change in the *p*H of the surrounding medium with strong acids or bases or the commonly used buffers apparently does not lead to an accumulation of hydrogen ions in the cell. A weak acid, however, that easily penetrates in molecular form and dissociates in the cell may in certain circumstances be able to cause an intracellular accumu-

lation of hydrogen ions, when changes may be expected in the dissociation of cell substances. It may further be expected that a certain number of ions will be freed which, if the membrane is permeable to them, may leave the cell. In yeast cells potassium, calcium and phosphate ions may chiefly be concerned here.

Sodium fluoride enters the yeast cell as hydrogen fluoride[4], which may cause an accumulation of hydrogen ions in the cell. At the same time, potassium leaves the cell[4,5]. For this reason it was of interest to examine the influence of fluoride on the charge of the yeast cell. This examination showed that the greater the concentration of sodium fluoride is in the surrounding solution, the lower is the electrophoretic mobility and the more apparent the agglutination of the cells. After the sodium fluoride has been washed out, the cells again behave as normal.

It seems that lower concentrations of sodium fluoride, which still cause stimulation of the respiration and fermentation of the cell, enhance the migration of the yeast cell toward the cathode.

It is interesting in this connexion to recall the tenacity with which erythrocytes[6] and bacteria[7] maintain their electrophoretic charge and mobility in spite of important changes both in the surrounding medium and, in the case of erythrocytes, even in the cells themselves (alterations in shape, hæmoglobin content, etc.). However, with the aid of the weak acids carbon dioxide and acetic acid, Höber[8] succeeded in changing the sign of the electrical charge of erythrocytes.

MIGNON MALM

Wenner-Gren's Institute for Experimental Biology,
University of Stockholm.
April 18.

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Crack-Heal Mechanism of the Growth of Invisible Films on Metals

THE thickening of oxide or other films on metals according to the parabolic equation $y^2 = K_1 t + K_2$ (where y is the film thickness at time t and all K's are constants) is generally attributed to lattice-defects, K_1 being related to the electrical constants of the film substance by Wagner's equations[1]. Logarithmic thickening ($y = K_3 \log (K_4 t + K_5)$ is, in my view[2], associated with discrete mechanical breakdowns caused by the strains arising from the volume increase accompanying oxidation: evidence of such strains is provided by the wrinkling observed during film-stripping[3].

In studying the invisible films formed on unheated iron exposed to air, a liquid giving conditions on the border-line between corrosion and passivity (preferably a sodium carbonate–bicarbonate buffer) has been used to show up major discontinuities as rust spots. The higher the concentration, the fewer the spots developed, since rust only appears if the outward effusion of metal exceeds inward diffusion of inhibitor, and at high concentrations this condition will only be fulfilled at exceptionally large discontinuities; thus the spots represent a 'selection' and not a 'sample', becoming increasingly 'select' with rising concentration. A scratch-line traced on heat-tinted metal serves conveniently as experimental area, steel being preferable to soft pure iron. A steel specially prepared for another research by the late Dr. Swinden[4] was used. It was abraded, degreased, tinted by heating in air for 40 min. at 270° C. and engraved with a blunted gramophone needle loaded at 200 gm. on a modified Mears–Ward machine[5]. Prints were taken at intervals on filter paper wetted with the solution (0·01 *M* in *each* salt); the inconspicuous rust spots on the paper were afterwards darkened by conversion to Prussian blue or to a sepia image of metallic gold.

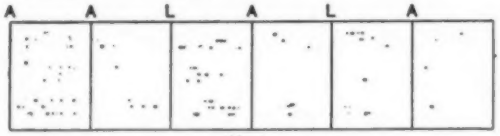

Fig. 1.

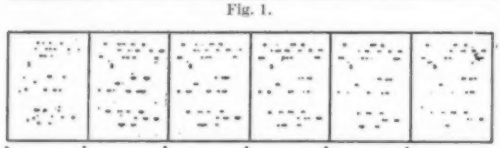

Fig. 2.

Fig. 1 shows the effect of 5-min. exposures at 25° C. alternately in air (*A*) and in the liquid (*L*) mentioned above. (Between each of these exposures there was a 5-min. contact with filter paper wetted with the liquid; the specimen was dried with filter paper before an air-exposure.) It will be noticed that after air-exposure most of the old spots disappear; but some new spots appear and still more arrive during the following immersion in liquid. This after-effect does not last long; Fig. 2 shows a single air-exposure followed by five liquid-exposures, and after the first, the pattern becomes nearly constant. These results have been obtained repeatedly, and other experiments support the idea that the *primary* effect of air-exposure is to heal existing pores, and the *secondary* effect to introduce new ones; the two effects are evidently interconnected, and we are led to a mechanism for oxidation under conditions unfavourable to lattice-defect migration.

Metal exposed (unwetted) to cold air must suffer oxidation at any pores present in the invisible film; the effect will be to block the original pores but introduce strains capable of cracking the film and producing new pores elsewhere. Thus the sequence crack - heal - crack - heal is set up, and it might be expected that the oxidation-rate would settle down to that constant value at which the cracking caused by oxidation balanced the oxidation produced by cracking ($dy/dt = K$). But in addition to (chemical) blockage connected with conversion of metal to oxide at the *base* of a pore, there may be some alternative (physical or mechanical) type of blockage which can occur *anywhere* on a pore; (to give just one example, the pore might 'weld up'). The oxidation-rate should then fall off as the film thickens, the pores lengthen, and the proportion of pores suffering physical blockage increases; for physical blockage contributes nothing to oxidation. If the chance of physical blockage in thickness-element dy is defined as pdy, the chance of *escaping* it in the full film-thickness y is $\exp -py$, and the equation becomes $dy/dt = K \exp -py$, which is just the relation ($y = K_3 \log (K_4 t + K_5)$) found by Vernon, Akeroyd and Stroud[6] on zinc exposed to fairly pure air; apparently p is small in polluted air, since Vernon[7] found a rectilinear law ($dy/dt = K$) for zinc in the London atmosphere.

This treatment is in many respects an over-simplification. It is hoped to publish later a more detailed discussion, taking account of the manner in which corrosion at any point depresses the probability of attack in the vicinity—as found by Mears and me[8]. Means of overcoming this statistical complication suggest themselves, and it may be possible to obtain curves showing how the frequency of pores of each size-class diminishes with time, and thus obtain detailed knowledge of the oxidation process.

Meanwhile, it appears unnecessary—in the case of iron and zinc—to postulate *ad hoc* mechanisms for the film growth, since the known facts are explained by the heal - crack - heal sequence, of which these experiments provide ocular evidence.

I would thank Mr. D. Whitwham for preparation of materials and photography of results, Prof. N. F. Mott and Dr. W. H. J. Vernon for useful discussion, and Dr. A. J. Gould for help in various ways.

U. R. EVANS

Metallurgical Laboratory,
University, Cambridge.
March 16.

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Combustion of Carbon

IT was pointed out by Nicholls[1] in 1933 that when an attempt is made to set up a heat balance from data relating to temperature measurement and gas composition within a fuel-bed in active combustion, there is an anomalous disappearance of energy at the point in the bed where the oxygen concentration becomes insignificant and the carbon dioxide concentration attains its maximum value. This observation has been confirmed by later workers[2], who have also shown that the 'missing' energy reappears as the gases further traverse the bed.

The conditions in a burning bed of solid fuel particles represent a departure from those of refined laboratory experiments in two main respects: (*a*) irregularity and time-dependence of the geometry of the surfaces of the fuel particles; (*b*) complexity of the chemical nature of the fuel and of the processes leading to ignition and combustion.

In order to study problems of energy release and the mechanism of oxidation reactions occurring in such systems without the above complications, it was found useful to employ a tube of elementary carbon, the conditions within which would approximate to those obtaining in a single channel in a fuel-bed. A slow air stream was passed through the tube, which was also electrically heated to an effectively steady state in which the electrical energy input was very large compared with the heat released by its combustion.

It was considered probable that the main cause of the above energy discrepancy lay not in the temperature measurements but in the technique of sampling the gases which, if they still contain oxygen and carbon monoxide, may continue to react after being drawn into the sampling probe. Attempts were therefore made to achieve more effective quenching by the use of very fine probes which were water-cooled to the extreme tip.

With the aid of these sampling tubes, it was established that the gas within a fraction of a millimetre of the carbon wall contained appreciable carbon monoxide (0·5–2·0 per cent), thus justifying in some measure the suggested cause of the energy discrepancy (unless drastic quenching is achieved, virtually no carbon monoxide is found so long as there is surviving oxygen). Away from the wall, however,

the carbon monoxide content of the gas was negligible, so that little positive evidence was forthcoming in favour of the theory advanced by Bangham and Thring[2,3], according to which about half the release of energy in fuel-bed combustion takes place in the voids between the fuel particles.

Quite a different state of affairs was revealed, however, when an attempt was made to 'freeze' the gas mixture by the aid of chemical inhibitors. (Other workers have resorted either to the use of low gas pressures—thus minimizing the probability of collision of the surface products with other molecules in the region of the reaction zone[4]—or alternatively to the use of normal pressures and low fuel-surface temperatures[5].) The use of carbon tetrachloride and phosphorous oxychloride was suggested by the work of Dufraisse and his collaborators[6,7]. The effect of chlorine has also been examined. When small quantities of these materials were included in the air-stream (which was dried over sulphuric acid and magnesium perchlorate) greatly increased quantities of carbon monoxide were found in the samples taken about 1 mm. from the carbon wall. The accompanying table demonstrates this and gives in each case representative observations after reaching a steady state.

Inhibitor	% by volume of inhibitor in air-stream	Gas analyses (%) CO_2	O_2	CO	Temp. at carbon wall 1 cm. upstream of sampling point (° C.)
Cl_2	0	17·5	2·5	0·6	775
	1·0	10·1	2·4	14·6	770
	1·0	9·6	1·2	15·5	770
CCl_4	0	14·6	5·8	0·7	815
	1·8	8·8	4·4	14·3	800
	1·8	8·2	1·9	16·1	795
$POCl_3$	0	16·3	4·1	0·6	805
	0·9	5·0	2·6	21·1	785
	0·9	5·5	2·9	22·3	785

Note.—The CO_2 figures with the inhibitors present include small amounts (< 1 per cent) of chlorine.

While it must remain for further experiments to establish whether or not these added materials also influence the surface reaction (by causing a large increase in the ratio of carbon monoxide to carbon dioxide in the gases leaving the carbon surface), the above results by themselves indicate that they function very efficiently as inhibitors of the gas-phase reaction, since appreciable quantities of oxygen and carbon monoxide co-exist in the gas. Thus a supposed effect on the surface reaction only is insufficient to account for the results. (Unpublished experiments by K. D. Wadsworth have suggested that carbon tetrachloride has little effect on the time of ignition of coal surfaces as measured under standardized air-flow conditions.) The marked effect of the halogens and their compounds on the ignition temperature and oxidation of carbon monoxide (and other combustible gases) has been frequently demonstrated[8]. The suppression of the gas-phase oxidation recorded above is presumably effected by a reactive species removing an essential link in the chain mechanism mainly responsible for the oxidation.

These experiments therefore strongly suggest that: (*a*) very rapid quenching is of the first importance when a reliable analysis is required of a hot gas mixture containing carbon monoxide and oxygen; (*b*) the bulk of the energy discrepancy first recorded by Nicholls is due to deficiencies in the gas-sampling technique; (*c*) the high-temperature oxidation of carbonaceous fuels takes place by a mechanism in which the gas-phase oxidation of carbon monoxide plays a significant part.

J. R. ARTHUR

British Coal Utilisation Research Association,
13 Grosvenor Gardens,
London.
March 27.

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Resonance Energy of the Tetrachlorethylene Molecule

RECENTLY[1], it has been shown that the interpretation of a general potential function determining the modes of vibration for the C_2Cl_4 molecule supports the hypothesis of resonance among several electronic structures, leading for the C—C bond to a single-bond character of about 15 per cent. This result has been deduced partly from the fact that the C—C force constant lies between 8·0 and 8·5 × 10^5 dynes/cm., as compared with 9·0 × 10^5 dynes/cm. for ethylene, and partly from general considerations on the signs of the cross-terms. (From a private communication from Prof. C. Manneback, we adopt 9·0 instead of 9·3 as in our previous publications; in this case, the conclusions are even reinforced.) If so, following Pauling's arguments[2], the actual energy of formation of the molecule must be greater than the calculated value by a certain amount, called resonance energy of the system. The definite bond diagram used for our calculation corresponds to the classical distribution of valencies and gives

$$C_2Cl_4\ (gas) = 2\ C\ (gas) + 4\ Cl\ (gas) - E\ (C{=}C) - 4\ E\ (C{-}Cl)$$
$$2\ C\ (gas) = 2\ C\ (diamond) + 2\ Lc$$
$$C_2Cl_4\ (gas) = 2\ C\ (diamond) + 4\ Cl\ (gas) - Q_{calc.}$$

It is to be noted that the value $Q_{calc.} = E\ (C{=}C) + 4\ E\ (C{-}Cl) - 2\ Lc$ is not influenced by the not yet definitely established value of Lc. According to Pauling[2], the C=C bond energy is 100 kcal./mole, the the C—Cl bond energy is 66·5 kcal./mole and Lc is 124·3 kcal./mole. Hence the heat of formation $Q_{calc.}$ is 117·4 kcal./mole.

The effective heat of formation $Q_{obs.}$ of the tetrachlorethylene gas molecule remains now to be determined from the heat of combustion and the heats of formation of the products of combustion.

Following the experimental results obtained by Thomsen and adopted by Bichowsky and Rossini[3], we obtain $Q_{obs.}$ = 108·3 kcal./mole. (In a private communication, Dr. Rossini has given us arguments against the alternative determination of the heat of combustion of C_2Cl_4 by Berthelot[4]. It leads to a value in the range of 150 kcal./mole for $Q_{obs.}$, which is considerably different from that obtained from Thomsen's data. Nevertheless, we cannot consider this value as completely ruled out.) In spite of the slight negative discrepancy between $Q_{calc.}$ and $Q_{obs.}$ (− 9·1 kcal /mole) the idea of resonance must not necessarily be abandoned, as this discrepancy lies within the limits of the probable errors in the experiments.

In any event, new and accurate measurements for the chlorinated hydrocarbons are of great importance for the further development of the question of determining the resonance energy by the Pauling method.

JULES DUCHESNE

Department of Physical Chemistry,
University of Liège.
March 20.

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Saturated Adsorbed Films and the Structure of Deeply Super-cooled Water

DR. F. C. FRANK, in a recent note[1], has directed attention to the work of Rau[2] who, by a process of repeated freezing and thawing which 'sterilized' the nuclei of solidification, succeeded in supercooling water to − 72° C., at which temperature it invariably froze. The water was in the form of droplets (up to a few millimetres in diameter) supported on a highly polished surface of chromium or nickel. The system being enclosed, so that the cooled metal plate was its coldest part, it is certain that the vapour in contact with its surface was saturated.

The point of special interest to which Frank directs attention is that the droplets flattened below − 50° and spread to a film at − 70° C. in other words, the equilibrium contact angle decreases markedly in this region.

The purpose of this note is to emphasize that these facts as stated do not imply that the surface tension of water decreases with fall of temperature in this region[1]. What the contact angle measures is not the surface tension of the liquid, nor yet the wetting free-energy, but the degree of incongruity between the molecular patterns of the saturated adsorbed film on one hand and of the liquid water surface on the other[3]. Adsorption experiments have made it clear that in the presence of saturated water vapour the metal surfaces would be coated with adsorbed films of water, almost certainly of more than unimolecular thickness. These films are none the less significant because they are invisible.

The molecular configuration in films which (like that of water on charcoal) may be three or four molecules in thickness and yet not render the surface completely *wettable* has been a preoccupation of mine for a number of years. It may be noted, in this connexion, that the 'introvert' configuration—postulated by Frank[1] for the supercooled water and characterized by formation of small closed groups which behave kinetically as complex molecules between which only the relatively weak van der Waals forces are acting—is similar to that assigned by me to the films of lower alcohols on charcoal on the basis of the measured properties of the latter[4].

The correct interpretation to be placed upon Rau's observations is, therefore, that as water is cooled below − 50° C., its molecular pattern and especially, in all probability, that of its surface layers, approaches more and more closely that characteristic of the films formed by adsorption of water vapour on the metal surfaces.

Whereas, with water (and the alcohols), hydrogen bonds beyond doubt play an important part in determining the configuration of the 'introvert' groups, it must be strongly emphasized that their presence is in no way essential for the formation of molecularly thick films in which the molecular pattern differs from that of the normal liquid. Thus, by exposing plates of mica to jets of the supersaturated vapours, it was found possible, both with polar and non-polar liquids, to build up films of visible thickness upon which drops of the normal liquids would not spread[5]. The contact angles were therefore finite, indicating a configurational difference between drops and films.

D. H. BANGHAM

British Coal Utilisation Research Association,
13 Grosvenor Gardens,
London, S.W.1.

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Elimination of Divergencies in Quantum Electrodynamics and in Meson Theory

A DIVERGENCE-FREE theory of the classical electron has been given by Wentzel, and then, with other methods, by Dirac. In quantum theory these methods give an elimination of part of the infinite expressions. Making further the assumption of positive- and negative-energy photons, Dirac eliminates all the infinite expressions.

The theory of the radiating classical electron is governed by the wave equation. Hadamard gave by his concept of 'partie finie' a meaning to divergent integrals which appear in the formal solution of the wave equation. M. Riesz[1] gave a new mathematical treatment of the wave equation, showing that the divergent integrals can be avoided. This method of solution applied to the electron gives an equation of motion which is identical with Dirac's equation for the classical electron. Applications of the method to the classical theories of the electromagnetic and meson fields are described in a paper by Fremberg[2].

We will now use these mathematical methods in quantum theory, treating as examples expressions, for example, the interaction energy, where divergencies appear already in second approximation when using ordinary methods. We use the formalism in which the dynamical equations are operator equations, giving the variation with t of the matrices. We treat first the interaction of a nucleon field ψ, which satisfies Dirac's wave equation, and a scalar meson field Φ.

$$\left[\frac{i\hbar}{c}\frac{\partial}{\partial t} + i\hbar\alpha_i\frac{\partial}{\partial x_i} - \beta mc\right]\psi = \frac{g}{c}\Phi\beta\psi$$

$$\Box\,\Phi + \varkappa^2\,\Phi = -\,g\psi^*\beta\psi.$$

We assume the usual commutation relations. Using second quantization for the nucleon matrix wave function $\psi(x,t)$, we expand ψ in a series of plane waves with matrix coefficients $a_n(t)$. We discuss the self-energy terms in second approximation, first the term

$$W_1 = \frac{g^2}{2}\iiint dV\,\psi^{0*}\beta\,\psi^0\Phi^1.$$

Here Φ^1 satisfies the meson equation with the right-hand member $-\psi^{0*}\beta\psi^0$. The solution of this equation by analytical continuation according to Riesz is

$$\Phi^{1\alpha} = -\iiint_{D_S^P}\psi^{0*}(Q)\beta\,\psi^0(Q)\left(\frac{r_{PQ}}{\varkappa}\right)^{\frac{\alpha-4}{2}}\frac{J_{\frac{\alpha-4}{2}}(\varkappa r_{PQ})}{2\pi 2^{\alpha/2}\,\Gamma\left(\frac{\alpha}{2}\right)}dQ.$$

Here r_{PQ} is the Lorentz-distance between the four-dimensional points P and Q. The integration over $dQ = (cdtdx_1dx_2dx_3)_Q$ is taken over the whole four-dimensional domain bounded by the retrograde light-cone with its top at P and by the space S at the time $t = T$ (in the meson case $T = -\infty$).

$\Phi^{1\alpha}$ is an analytical function of α. The solution of the meson equation is obtained by analytical continuation in α to $\alpha = 2$ (see refs. 1 and 2). We insert $\Phi^{1\alpha}$ into W_1 and get an expression $W_1{}^\alpha$. Neglecting the retardation and retaining the terms not zero in the one-nucleon case, we find in the integrand of $W_1{}^\alpha$ a sum

$$\sum_n \exp\left(\frac{i}{\hbar}k_n(X_P - X_Q)\right) = \delta(X_P - X_Q).$$

We find:

$$W_1{}^\alpha = -\frac{g^2\,\varkappa^{1-\alpha}}{4\pi\,2^{\alpha/2}\,\Gamma\left(\frac{\alpha}{2}\right)}\int_0^\infty \tau^{\frac{\alpha-4}{2}}\,J_{\frac{\alpha-4}{2}}(\tau)\,d\tau.$$

The integral is convergent for $3 < \alpha < 5$ and is for these α's equal to

$$2^{\frac{\alpha-4}{2}}\,\Gamma\left(\frac{\alpha}{2} - \frac{3}{2}\right)\Gamma\left(\frac{1}{2}\right).$$

This expression, and therefore $W_1{}^\alpha$, can be continued analytically to all α. Now Φ^1 has to be a solution of the meson wave equation. This is achieved by putting $\alpha = 2$. So we find that W_1 or the energy (when neglecting the retardation) of the meson field created by a point nucleon has a finite value $g^2\varkappa/8\pi$.

We make a comparison with the electrostatic energy of a point charge. The equations for this case are obtained by substituting in the interaction terms 1 and -1 for the first and second β, respectively, which only alters the sign of the energy, and then by putting $\varkappa = 0$. Thus we find the value zero for the electrostatic energy of a point charge. We have also found this value in another way[3].

We proceed to the other self-energy term of second approximation, the integrand of which is $(\psi^{1*}\beta\psi^0 + \psi^{0*}\beta\psi^1)\Phi^0$. It is the energy of the forced oscillations of the nucleon produced by the meson vacuum field fluctuations. When assuming Dirac's theory of positive- and negative-energy mesons, the divergence diminishes by one order. A fuller account of the meson case will be given elsewhere[4].

We wish to stress the circumstance that in the calculations above, the solution of the meson field equation has been obtained by analytical continuation, whereas the Dirac wave equation has been solved in the ordinary way. The Dirac equation is also, however, a hyperbolic equation, the solution of which and, thereby, the corresponding energy expressions, can also be given by analytical continuation. I hope to be able to return to these questions later.

TORSTEN GUSTAFSON
Institute for Mechanics and Mathematical Physics,
University of Lund.
March 12.

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Preparation of Synthetic Quartz

A RECENT communication directs attention to the crystallization of silica glass to give small quartz crystals[1]. My experience in the hydrothermal synthesis of quartz may be of interest in view of this letter and of the industrial importance of this mineral.

A partial or complete crystallization of silicic acid gel was obtained by heating the gel in an autoclave with potassium carbonate or sodium carbonate solution for three days at ~ 350° C. to 390° C. Quartz was the only crystalline species present. The birefringent crystals were small but often beautifully formed, and frequently revealing the striations and hemihedral faces seen in perfect natural crystals. Along with other species such as analcite, quartz was also obtained by hydrothermal crystallization of aluminosilicate gels. These were prepared by stirring sodium aluminate solution into silicic acid suspension, and evaporating to dryness; the crystallization was effected in media of water, sodium carbonate solution and sodium bicarbonate solution at temperatures ranging between ~ 255° C. and ~ 355° C. After crystallization, the *p*H of the cold mother liquor in all cases lay in the range 8·5–10·5, that is, the liquor was alkaline. Gels of compositions $NaAlO_2{\cdot}6{\cdot}15SiO_2$; $NaAlO_2{\cdot}5{\cdot}47SiO_2$; $NaAlO_2{\cdot}4{\cdot}68SiO_2$; $NaAlO_2{\cdot}4{\cdot}108SiO_2$ usually gave *inter alia* yields of quartz, though often small in amount compared with other species. Mixtures poorer in silica than the above did not give any quartz under these alkaline conditions. It was concluded that alkali is a good selective mineralizer for quartz in silica-rich mixtures only, from which under the above conditions quartz is easily formed.

It must not be thought that synthetic quartz formation is rarely reported. Experiments have been made quite similar to those described by Wooster and Wooster[1], in which various glasses (crown, borosilicate and flint[2]; thuringian and obsidian[3]; silica glass[4]; glass powder[5] and minerals (muscovite[6]; tridymite and cristobalite[6]) have been crystallized or recrystallized. Crystallizations of various gels and mixtures (for example, silica gel[7] and sol[8,9]; alkali, $Al(OH)_3$ and $Si(OH)_4$[10]; K_2SiO_3, KOH and $Al(OH)_3$[11,12,13]; and a variety of others) have been equally successful[14,15]. There is thus abundant material to draw on in attempts to make quartz on a large scale.

It is also of interest that the formation of tridymite[2,3,11,13,14] and cristobalite[17,18] has been reported under similar hydrothermal conditions to those for making quartz, and so in a metastable temperature range. It is thus likely that all the variables are not yet realized.

R. M. BARRER
Chemical Laboratories,
Technical College,
Bradford.
March 22.

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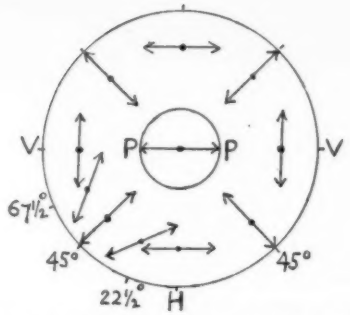
[5] Bruhns, Neues Jahrb. Min., (ii), 62 (1889).
[6] Friedel, *Bull. Soc. min. franc.*, **19**, 5 (1896).
[7] de Senarmont, *Ann. chim. phys.*, (3), **32**, 142 (1851).
[8] Chrustchoff, *Bull. Soc. min. franc.*, **10**, 31 (1887).
[9] Chrustchoff, *C.R. Acad. Sci., Paris*, **104**, 602 (1887).
[10] Friedel and Sarasin, *Bull. Soc. min. franc.*, **2**, 113 (1879).
[11] Friedel and Sarasin, *Bul. Soc. min. franc.*, **2**, 158 (1879).
[12] Friedel and Sarasin, *Bull. Soc. min. franc.*, **3**, 25 (1880).
[13] Friedel and Sarasin, *Bull. Soc. min. franc.*, **4**, 171 (1881).
[14] Bauer, *Z. phys. Chem.*, **42**, 567 (1902).
[15] Allen, *Amer. J. Sci.*, (4), **22**, 297 (1906).
[16] Schlaepfer and Niggli, *Z. anorg. Chem.*, **87**, 52 (1914).
[17] Weil, *C.R. Acad. Sci., Paris*, **181**, 423 (1925).
[18] Ewell and Insley, *J. Res. U.S. Bur. Stand.*, **15**, 173 (Reprint 819) (1935).

Scattering of Polarized Light by a Colloidal Graphite Solution

THE first Lord Rayleigh dealt with the scattering of plane polarized light seventy-five years ago[1]. In the theoretical treatment it is assumed that the colloidal particles are spherical. A newly prepared solution of colloidal sulphur is usually employed to demonstrate his results, and the observations indicate that no light is scattered in the plane containing the electric vector. (This is the direction marked on 'Polaroid' disks, and I will here adopt the convention of calling it the plane of polarization.)

Consider a beam of plane polarized light directed vertically downward on a cylindrical glass absorption cell with its upper surface covered with a plane window. The cell is filled with a weak suspension of 'Aquadag' colloidal graphite in water. Observations are carried out in a horizontal plane, and either the observer moves around the tube in a circle, or the polarizing 'Polaroid' is rotated. The diffused light appears almost equally bright when viewed from any direction horizontally. If, however, a 'Polaroid' is placed before the eye, it is found that the light is nearly completely plane polarized, the inclination of the plane of polarization being related to the angular position of the observer as indicated in the diagram, where *PP* repres-



ents the plane of polarization of the vertical beam and the observer is supposed to move around the circle turning his analysing 'Polaroid' as indicated by the arrows.

An explanation of the effect is suggested by the following experiment. A graphite surface is mounted in a beaker of water so as to be inclined at 45° to the vertical, and a beam of plane polarized light is directed on it vertically downwards. As the beaker is rotated, the horizontal reflected beam is found to vary as regards the orientation of the plane of polarization in much the same manner as the scattered light from the solution, although complete extinction is not obtained in this case. It is therefore suggested that the graphite particles are in the form of (hexagonal) flakes which are, of course, chaotically oriented. At any instant a number of them will be so inclined as to reflect the light in the direction of the eye. The inclination of the plane of polarization of the scattered light will then depend on the angle between the plane of polarization of the incident (vertical) ray and the plane of incidence (and observation).

I have not found any previous reference to this phenomenon, which is possibly of sufficient interest for record.

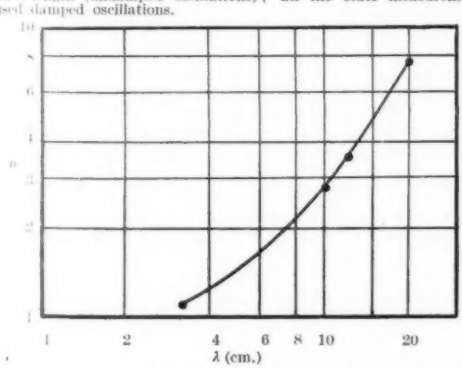
JOHN J. DOWLING

University College,
Dublin.
April 3.

[1] Strutt, *Phil. Mag.*, **41**, 107 and 274 (1871).

Magnetic Permeability of Nickel in the Region of Centimetre Waves

It is well known that the magnetic permeability of ferromagnetic materials decreases towards unity in the region of centimetre waves. The measurements by Hoag and Jones[1] extend only down to 20 cm. wave-length (undamped oscillations); all the older measurements used damped oscillations.



In order to check the theory of the effect[2], I made measurements with undamped oscillations of four wave-lengths ranging from 3·20 cm. to 29·1 cm. The shielding effect of a thin foil of the investigated material placed between coupling loops of the transmission lines was measured. Films of pure nickel evaporated *in vacuo* on glass plates have been compared with silver films. The specific resistance of both films being known, the magnetic permeability can be computed. The results for nickel films about 1000–2000 A. thick are shown on the accompanying graph. As the energy of oscillations was relatively small (10–100 mW.), only films of low shielding power could be measured accurately and their thickness had to be small. It was also found that the static permeability decreases with the thickness from about 22 for 2300 A., to unity for zero thickness. The investigation is being continued.

I. SIMON

Institute of Physics,
Charles University,
Prague II.

[1] Hoag and Jones, *Phys. Rev.*, **42**, 571 (1932).
[2] Becker, *Z. Tech. Phys.*, **19**, 542 (1938).

Solubility and Heat of Solution of Caprylic Acid in Water

IN connexion with experiments on the foaming of aqueous solutions of capillary-active substances, we have determined the solubility of caprylic acid, m.p. 16·5° C., in water over the range 0–90° C.

At the higher temperatures we used a solution of known concentration and rapidly determined the temperatures at which milkiness appeared and disappeared. The mean was taken as the temperature of saturation. At the lower temperatures the acid was stirred with water at constant temperature in a large Dewar flask for some days, and eventually filtered through a plug of cotton-wool. The filtrate was sucked directly by a carefully regulated pump into a calibrated pipette. Concordant results were obtained by approaching the equilibrium from both sides at each temperature. Considerable time is necessary for the attainment of complete saturation from the unsaturated side, but supersaturated solutions come into equilibrium with the solid substance more quickly.

At the higher temperatures care is necessary to guard against the great volatility of the acid in water vapour.

The results obtained are as follows:

Temperature	Solubility
0·0° C.	0·0594 gm./100 gm. solution
6·1	0·0661 " " "
11·8	0·0714 " " "
18·8	0·0818 " " "
52·2	0·1322 " " "
89·5	0·1996 " " "

The simple logarithmic formula

$$\log_{10} c = a - b/T$$

describes the results accurately with $a = 0{\cdot}916$ and $b = 586$ and $T = °$ Absolute.

The heat of solution of the acid so calculated is -2680 calories per gram molecule. It is remarkable that no abrupt change is visible in the solubility curve when the temperature passes through the melting point of the acid.

A full account will be published later.

F. H. CONSTABLE
S. TEGUL

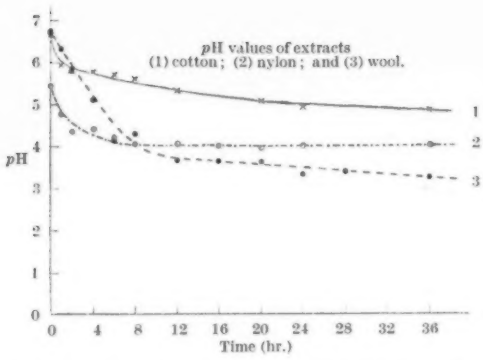
Institute of Physical Chemistry,
University, Beyazit,
Istanbul.

Effect of Heat on Wool, Cotton and Nylon

TEXTILE fibres, especially those included in certain mechanical cloths exposed during use to high temperatures, show obvious deterioration after the lapse of time. Thus, when aqueous extracts of such woollen and cotton cloths, so damaged, have been examined, they have always been found to be of relatively low *p*H value and high electrical conductivity as compared with extracts of the original material. Also, it has been observed that in cases where one side of a thick cloth is in contact with heated drying cylinders, there is a progressive increase in the *p*H values and a decrease in the conductivity figures of the extracts as one proceeds from the heated side. It was found, for example, that the fibres taken from the side of a woollen dry felt in contact with the heated cylinder gave a *p*H value of 3·82, whereas those from the middle and from the outside of the felt gave extracts of *p*H 4·46 and 5·36 respectively.

The adverse effect of high temperatures on the physical properties of these materials is well known, and figures showing the effect of heat on the strength, extensibility and weight of both wool and cotton have been published by Marsh[1]. A study of the effect of heat on the tendering of yarns and fabrics, including cotton, worsted and nylon, has been made by the British Cotton Industry Research Association[2]. In the case of cotton and nylon, the chemical effects of heat treatment do not appear to have been widely investigated, but in the case of wool some notes published by Woodmansey[3] deal with the evolution of ammonia and hydrogen sulphide. The development of acidity, due, in part, to the oxidation of wool sulphur to sulphuric acid, was noted. In a more recent work by Skiern and Rouette[4], the relationship between heat damage and the evolution of ammonia and sulphur-linkage breakdown under varying conditions of acidity and alkalinity is the subject of a detailed investigation, which also deals with the changes in thickness and tensile strength of fibres.

	*p*H values			Conductivity (dionic units)		
Heated at 150° F. for:	Wool	Cotton	Nylon	Wool	Cotton	Nylon
Control	6·74	6·64	5·47	124	12	8
1 hr.	6·29	5·93	4·76	183	25	18
2 "	5·80	5·83	4·37	208	29	21
4 "	5·10	5·77	4·39	246	31	26
6 "	4·18	5·70	4·20	281	31	29
8 "	4·29	5·60	4·05	288	38	37
12 "	3·68	5·29	4·06	345	45	38
16 "	3·65	—	4·00	360	—	40
20 "	3·66	5·05	3·98	350	48	43
24 "	3·37	4·94	4·00	390	52	40
28 "	3·41	—	—	393	—	—
36 "	3·26	4·85	3·99	447	48	42



Extracts were prepared from 1 gm. of the material in 100 c.c. of distilled water heated on a water bath for one hour. The results of the preliminary investigations indicate that wool, cotton and nylon after treatment at 150° C. give progressively lower *p*H values and greater electrical conductivity with increasing length of time, as indicated in the accompanying table. The graph shows the effect of duration of heating on *p*H. In the case of nylon, the *p*H value and conductivity remained stationary after 12 hours, but at the conclusion of these experiments, after 72 and 142 hours treatment respectively, wool and cotton were still changing at approximately the same rate as after 24 hours.

The present work, a full account of which will be published at a later date, aims at amplifying the knowledge of the effect of heat on wool, cotton and nylon by a quantitative study of the relationship between heat damage and changes of *p*H value and electrical conductivity at various temperatures under different moisture conditions.

A. O. Lloyd

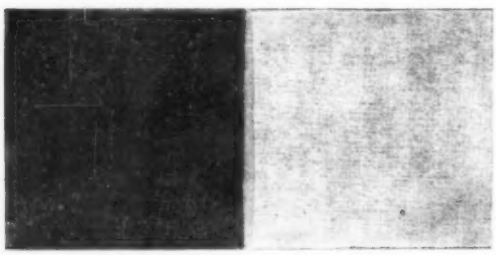
Research Department,
Porritts and Spencer, Ltd.,
Bamford, nr. Rochdale.
March 29.

[1] Marsh, *J. Text. Inst.*, **23**, T187 (1935).
[2] *Shirley Inst. Bull.*, 225 and 356 (1936); 134 (1937); 324 (1938); 13 (1945).
[3] Woodmansey, *J. Soc. Dyers and Col.*, **34**, 227 (1918).
[4] Skiern and Rouette, *Textilber.*, **16**, 4 (1935).

Use of Polymers to Immunize Wool Against Acid Dyes

It is difficult to reduce the affinity of wool for acid dyes by means of compounds which react simply to form condensation products with the basic side-chains. The latter are relatively inaccessible in the crystalline phase of the fibres, and where a successful 'resist' is obtained, for example, by acetylation in presence of sulphuric acid, it is because incomplete reaction is compensated by the introduction of sulphonic groups into the keratin molecule[1]. The net positive charge acquired by the fibres in acid solution is thereby reduced, thus ensuring that most, if not all, of the dye is acquired by the untreated wool when treated and untreated patterns are dyed in the same dye-bath. In the light of these observations, it seemed likely that a successful 'resist' might be obtained simply by forming an acid polymer within the fibres. The possibility was therefore examined as soon as a convenient method was developed for polymerizing monomers within textile fibres[2].

A 2·5 gm. sample of purified all-wool flannel was immersed in 25 c.c. of a 0·2 per cent solution of ferrous ammonium sulphate for 2 hours at 25° C., squeezed and dried. The pattern was then transferred to 125 c.c. of a solution containing the required amount of methacrylic acid and 0·5 c.c. of 6 per cent hydrogen peroxide, the solution being raised to the boil in 20 min. and boiled for 15 min. After being washed well in running water, the pattern was dyed at the same time as an untreated pattern in a bath containing 2 per cent of Polar Red G and 10 per cent of hydrated sodium sulphate, both percentages being based on the total weight of wool present. Several such experiments were carried out with patterns containing increasing amounts of polymethacrylic acid, a good 'resist' being obtained with 20 per cent of polymer in the wool, as is shown by the accompanying photograph of the dyed patterns. The effect is not due solely to the acidity of the polymer, because a less effective, though positive, 'resist' was obtained with 20 per cent of polymethyl methacrylate, showing that the rate of diffusion of dye into the fibres is reduced by the presence of an internal deposit of polymer.



CLOTH WITH 20 PER CENT POLYMER, DYED WITH POLAR RED G FROM A NEUTRAL BATH

The formation of 20 per cent of polymethacrylic acid within the fibres of a wool fabric has remarkably little effect on its feel, but there is reason to believe that the use of more strongly acid monomers will allow equally satisfactory 'resist' effects to be obtained with much smaller deposits of polymer.

One of us (M. L.) is indebted to the International Wool Publicity and Research Secretariat and the Australian Wool Board for grants which enabled him to take part in the investigation.

M. Lipson
J. B. Speakman

Textile Chemistry Laboratory,
University, Leeds.
April 20.

[1] Elliott and Speakman, *J. Soc. Dyers and Colourists*, **59**, 185 (1943); Elliott, *ibid.*, **60**, 273 (1944).
[2] Lipson and Speakman. [*Nature*, **157**, 590 (1946)].

Luminosity Curve of Trichromats

According to Helmholtz's theory of colour vision, luminosity is caused by the summed excitations of the three kinds of receptors. Granit[1], however, suggests that the luminosity is caused by a special type of receptor, the dominators, whereas the other (two) types (the modulators) only give the colour to the observed objects.

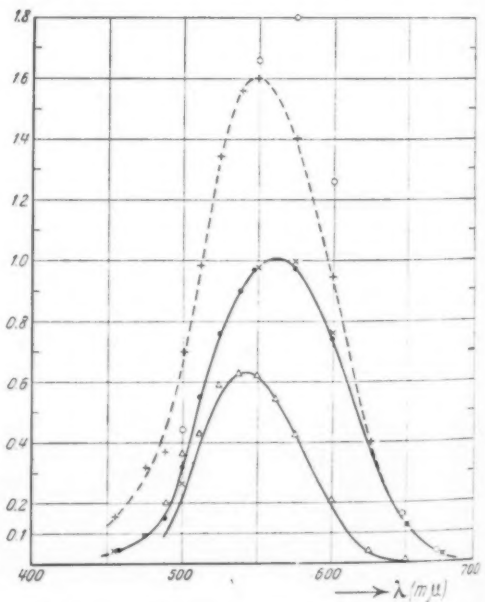
I believe that the measurements reported below can be explained by the first hypothesis only.

(*a*) It is well known that the luminosity curves of different persons show large differences[2], even when we confine ourselves to normal trichromats. Measurements of the sensitivity of twenty-two persons for $\lambda = 0{\cdot}550\,\mu$, expressed in terms of the sensitivity of my own (deuteranomalous) eyes, gave the following results:

104, 112, 115, 115, 121, 125, 128, 130, 130, 134, 140, 142, 142, 150, 166, 166, 166, 192, 193, 200, 208, 217.

Here arbitrarily the sensitivity at $\lambda = 0{\cdot}650\,\mu$ is set equal for all observers. (Generally, the sensitivity curves are drawn so that their maximum is 100.) These results show that the sensitivities may differ by a factor of 2.

In Helmholtz's theory this may be explained by the assumption that the ratios of the numbers of red and green receptors show large variations. On Granit's theory, these differences are difficult to understand. For example, differences in pigmentation cannot explain them, as the subjects showed very small differences in their colour-matches (Rayleigh test).



● Author's luminosity curve.
× Red curve of G.W.N. and author (solid curve).
○ Luminosity curve of G.W.N.
\+ Luminosity curve of B. (broken line).
△ Difference between red curve and broken line.
Points are on the 'green' curve.

Observer	Red curve			Luminosity curve		
	0·650	0·550	0·455	0·650	0·550	0·455
Author	12	100	5	12	100	5
N.	13	100	4	12	115	12
G.W.N.	12	100	5	12	166	—
B.	11·5	100	5	12	160	16
G.	12	100	–	12	220	—

(b) Further evidence for Helmholtz's theory is given by the following experiments. We determined the sensitivity curves of the red-receptors of five persons, by the new method already described by me[3]. Some of the results are given in the accompanying table.

It is seen that the red curves of these persons show only small differences, which are probably within the limits of error. Intentionally I have chosen three persons whose luminosity curves differed very much from my own curve.

The complete results for three observers are brought together in the accompanying graph.

The luminosity curve of G.W.N., represented by open circles, was determined for the same (rather high) brightnesses at which the red curve was measured, and therefore it was not possible for normal eyes to get very accurate results with the flicker-photometer. (For my own eyes, the measurements were very accurate.) The luminosity curve of B. was determined more accurately at a lower brightness level. The difference between his red curve and the luminosity curve, given by △, is the luminosity curve of protanopes. This curve is nearly identical with the green curve of normal trichromats. Indeed we have determined B.'s green curve from colour-mixture experiments, and the agreement with the curve shown was satisfactory.

These results are all in agreement with Helmholtz's theory. For the author's deuteranomalous eyes the contribution of the green receptors has nearly the same spectral distribution as that of the red-receptors (see ref. 3). Therefore here the red-curve and the luminosity curve coincide. For other observers the sensitivity in the green region is higher (not lower!).

Assuming the contribution of a certain type of receptor to be proportional to the number of receptors present, and taking into account the shape of the green curve, we find that the height of the luminosity curve is 160 if equal amounts of green and red receptors are active; the height becomes 220 if the ratio is equal to 3 : 1.

The colour-mixture apparatus used in these experiments was constructed in the workshop of our laboratory by permission of Prof. D. Coster. Furthermore, my thanks are due to all the observers who have assisted in the measurements.

Note added in proof. I would direct attention to reports of R. Granit in the *Acta Physiologica Scandinavica* (1941–44). The measurements and Granit's theory are given there in more detail, and they seem to be in good agreement with the measurements reported above.

HL. DE VRIES

Natuurkundig Laboratorium der
Rijks-Universiteit, Groningen.
March 6.

[1] Granit, R., *Nature*, **151**, 11 (1943).
[2] Judd, D. B., Research papers, Nat. Bur. Stand., **33**, 407 (1944).
[3] de Vries, HL., *J. Opt. Soc. Amer.*, **36** (Feb. 1946).

Planck's Radiation Formula

IN a recent communication[1], Prof. H. Dingle has obtained Planck's radiation law in the form

$$f(\psi\,;\,\nu) = \frac{A\nu^3\psi^{-1/4}}{\exp\,(B\nu\psi^{-1/4}) - 1}$$

as a solution of the equation

$$\int_0^\infty f(\psi\,;\,\nu)d\nu = \int_0^\infty f(\psi/\psi_1\,;\,\nu\psi_1^{-3/4})d\nu, \qquad (1)$$

subject to the conditions (i) $f(\varphi\,;\,\nu)$ independent of φ_1, (ii) $f(\varphi\,;\,\nu)$ not decomposable as a product $g(\varphi)\,h(\nu)$, and (iii) the integrals must converge.

Initially, Dingle conjectured that his equation might admit of only the one solution, but later[2], he showed this not to be so. It is possible to transform (1) into an equivalent relation with a more immediate physical interpretation. If we write

$$\nu\psi_1^{-3/4} = \nu', \quad F(\psi) = \int_0^\infty f(\psi\,;\,\nu)d\nu,$$

the equation becomes

$$F(\psi) = \psi_1^{3/4}\,F(\psi/\psi_1),$$

or

$$F(\psi) = k\psi^{3/4},$$

on putting $\psi_1 = \psi$. Thus (1) is equivalent to the statement

$$\int_0^\infty f(\psi\,;\,\nu)d\nu = k\psi^{3/4} \quad (k \text{ a constant}), \qquad (2)$$

which must correspond to Stefan's law in Dingle's theory.

Since (2) contains no information on the manner in which the total radiation is distributed between the different frequencies ν, it is clear that it will not be possible to establish Planck's formula (nor even the Wien displacement law) by any argument based on (1), unless some essentially new idea is introduced.

I should like to thank Prof. Dingle for kindly allowing me to see an advance copy of his second letter.

DAVID G. KENDALL

Magdalen College,
Oxford.
April 24.

[1] *Nature*, **157**, 515 (1946).
[2] *Nature*, [**157**, 556 (1946)].

I HOPED that my first letter on this subject would draw from some mathematician a statement on the uniqueness of the condition mentioned therein, and I am grateful to Mr. Kendall for responding and also for his kindness in sending me an early copy of his letter. From the physical point of view the position remains, I think, as stated in my second letter. The thermal relativity theory requires that the radiation formula shall satisfy a certain condition, which in fact it does. The theory is thus to that extent supported. The condition, however, is much less restrictive than I at first thought possible, and does not itself demand the Planck formula.

HERBERT DINGLE

Imperial College of Science and Technology,
London, S.W.7.

Stefan's Radiation Law

IT is stated in some text-books on heat that Stefan discovered the fourth power of the temperature law of radiation in this wise. He found, in one of John Tyndall's published researches, the statement that the radiation from a piece of heated platinum foil was 11·9 times as great when the foil was white-hot as when it was red-hot. Estimating these centigrade temperatures as 1,200° and 525°, and remarking that Nature worked in simple ways, he put

$$\left(\frac{1{,}200 + 273}{525 + 273}\right)^x = 11{\cdot}9,$$

and solved for x. The value is 4·05, whence he said x is obviously 4·0. Can anyone give me the reference in Tyndall's work to the above result? I have scanned Tyndall's books in vain.

JOHN SATTERLY

Department of Physics,
University of Toronto.

Biology in Italy

I HAVE had occasion to read lately in *Nature* two letters concerning the study of biology in Italy, one by Dr. A. Buzzatti-Traverso, in an article written by Dr. Julian Huxley[1], and the other by Mr. L. C. Beadle[2]. Since I fear that the character of the first letter is liable to generate an erroneous interpretation of biological activities in Italy, I wish to clarify some points, being myself a young biologist, and also in recognition of the friendships I made during my stay at the Zoological Department of Cambridge in 1937.

Dr. Buzzatti-Traverso states that: "Italian biology was not good even before the War", and that " . . . many professors of biology are wholly out of sympathy with modern ideas in this subject, and unlikely to be removed from their posts". He, and also Prof. Baldi, believe that modern institutes of biology in Italy should be developed outside the universities, like the Hydrobiological Institute at Pallanza and the Stazione Zoologica in Naples. I read with pleasure that Mr. Beadle found in Padua a well-equipped and up-to-date institute of biology; but there are others in Italy to-day still working actively. The War has certainly lowered to a considerable extent the potential possibilities of many institutes; but these consequences of the tragedy which has stricken our country would be light compared to the loss that would follow if modern biologists had really abandoned Italian universities!

I have here the last volume of Dr. J. Needham's "Biochemistry and Morphogenesis" (Univ. Press, Cambridge). This covers a very modern branch of biology and, of some 2,300 authors mentioned, about 150 are Italian. The great majority of these are university research workers, because there is a tradition in Italy that, for the most part, science is practised and studied in the universities.

The Stazione Zoologica at Naples is an example of the big institution on an international basis. It is not, and does not purport to be, a centre of studies in competition with the universities; its function is to furnish material and the means to study it. Here will be found both university and non-university research workers, not only Italians but of all nationalities.

ALBERTO STEFANELLI

Department of Histology and Embryology,
University of Rome.

[1] *Nature*, **156**, 576 (1945).
[2] *Nature*, **157**, 79 (1946).

RADIATION AND LIVING CELLS

A SYMPOSIUM was held at the British Institute of Radiology during May 13 and 14 under the general title of "Certain Aspects of the Action of Radiation on Living Cells". The four sessions dealt with the inactivation of viruses, the action of radiation on aqueous solutions, the action of radiation on chromosomes, and the effects of radiation on germ cells with special reference to man, respectively. In opening the symposium, the president of the Institute, Dr. L. H. Clark, emphasized that the subjects under discussion require the co-operation of workers in several fields.

In a paper dealing with the distribution of ions in irradiated tissue, Dr. L. H. Gray (Mount Vernon Hospital, Middlesex) said that the radiations under discussion were the alpha-, beta-, and gamma-rays of radium, X-rays, and neutrons. No effects of radiation are known which can be produced by one of these radiations and not by the others, but quantitative differences due to differences in the spatial distribution of ionization exist which sometimes lead to apparently qualitative differences. Thus, when studying the bean root, it is found that alpha-rays are more effective (per ionization) than gamma-rays in killing the root, but less effective in causing a temporary reduction of cellular division.

Inactivation of Viruses

Dr. Roy Markham (Plant Virus Station, Cambridge) described experiments on the irradiation of crystallizable plant viruses which show that a virus particle can be inactivated by a single ionization, and that an ionization produced at random in the virus particle has a probability of about one quarter of causing inactivation. Dr. P. Bonét-Maury (Institut du Radium, Paris) described a method of irradiating animal viruses and bacteriophages by alpha-rays emitted by radon gas dissolved in the virus solution. When the logarithms of the fractions of the virus activity surviving are plotted against the dose, straight lines are obtained, from the gradients of which it is possible to calculate the 'target' size of the virus, that is, the size on the assumption that every virus particle traversed by an alpha-particle is inactivated. On the whole, there is good agreement between the target sizes and the sizes of the viruses determined by other methods.

Using X-rays, Bonét-Maury and Frilley found that vaccinia virus, and the virus of foot-and-mouth disease, are inactivated at nearly equal rates, despite the fact that vaccinia is much the larger virus, and despite the fact that vaccinia is many times more sensitive to alpha-rays. It is concluded that vaccinia, unlike the small viruses, cannot be considered to be a homogeneous entity, and must contain sub-units perhaps of size comparable to the foot and mouth virus particle.

Dr. M. H. Salaman (Strangeways Laboratory, Cambridge) described experiments on the inactivation of vaccinia virus and of three bacteriophages by gamma-rays, X-rays and alpha-rays. It is found that with any given virus the inactivation doses increase in the order of increasing ion-density, namely, gamma-rays, X-rays, alpha-rays. In the case of a small phage (*S*–13) the 'target' sizes deduced from experiments with the three radiations agree with each other, and also with the known size of the virus. With larger viruses, especially vaccinia, the 'target' sizes are not the same for all radiations, and are smaller than the true size of the virus. These results can be interpreted to mean that the smallest viruses are 'macromolecules' or 'naked genes', while vaccinia is more akin to a unicellular organism.

Dr. D. E. Lea (Strangeways Laboratory, Cambridge) pointed out that virus inactivation is predominantly indirect in dilute solutions, and predominantly direct in concentrated solutions; this suggests that the direct and indirect action interpretations of the biological action of radiation are complementary rather than rival theories.

Summarizing, this session showed that there is agreement that a virus particle can be inactivated by a single ionization, and that the smallest viruses behave as 'macromolecules' or 'naked genes', while the largest viruses are more complex. In discussion, Prof. N. F. Mott (University of Bristol) and Dr. W. A. Waters (Oxford) pointed out that, in a molecule or in a crystal, there is the possibility that the gap produced by the ejection of an electron from an atom may wander, so that the effect observed may be in a part of the molecule or crystal remote from the particular atom ionized.

Radiation and Dilute Aqueous Solutions

Dr. C. B. Allsopp (Guy's Hospital, London) reviewed experimental data which show that a large number of substances, when irradiated in aqueous solution, undergo chemical change, the number of molecules reacting, over a wide range of concentrations, being proportional to the ionization produced in the solution as a whole and not to the ionization produced directly in the solute molecules. This shows that ionization or excitation of water is able to lead to the production of an intermediary body, until recently described as 'activated water'.

Dr. W. M. Dale (Christie Hospital, Manchester) described experiments on the inactivation of the enzyme carboxypeptidase in aqueous solution, and showed that the effect is predominantly indirect even in a 14 per cent solution. Alpha-rays are less effective than X-rays (ionic yield 0·16 for X-rays, and of the order of 0·01 for alpha-rays). A variety of substances present in the solution are able to protect the enzyme (by competing for the 'activated water'), and some interesting differences in the protecting power are exhibited by different substances. Thus formate is two hundred times more effective as a protective agent than oxalate (per unit mass).

Dr. M. Frilley (Institut du Radium, Paris) described experiments on the production of hydrogen peroxide by the irradiation of water. The yield increases slightly less rapidly than the first power of the dose, is the same for equal doses of alpha-rays and X-rays, and is not changed by fractionating the dose.

Dr. J. Weiss (King's College, Newcastle) described the mechanism he has proposed as the explanation of the indirect effect in aqueous solution. Ionization or excitation of water leads to the formation of free hydrogen atoms and hydroxyl radicals. In the absence of dissolved substances these largely recombine, but if solutes are present the radicals may react with the solute molecules. Thus oxidation and reduction of inorganic ions, the production of hydrogen peroxide in oxygenated water, and the dehydrogenation of organic compounds can be explained. With the high ion-densities present in alpha-ray columns, combination of radicals may be expected to occur, thus explaining the low ionic yields in experiments such as those of Dale (see also *Nature*, May 4, p. 584).

Dr. D. E. Lea described the manner in which the radicals initially produced by an alpha-ray in a column of diameter of the order 0·03 μ may be expected to spread by diffusion; he concludes that recombination of radicals (or action with any solute present) is rapid enough to ensure that the radicals in each column practically disappear before sufficient time elapses for adjacent columns to overlap.

Dr. W. A. Waters mentioned that in most solutions free radicals have a very short life owing to reaction with solute or solvent, but that this would appear not to be true of hydrogen atoms and hydroxyl radicals in pure water.

Summarizing, it seemed to be agreed that a strong *prima facie* case had been made for the view that indirect actions in aqueous solution are due to the production of free hydrogen atoms and hydroxyl radicals, but that a number of important experimental results remain to be explained.

Action of Radiation on Chromosomes

Dr. F. Ellis said that it is becoming clear that chromosome changes play an important part in the killing of cells by radiation, and the subject is therefore of great interest to radiotherapists.

Dr. D. G. Catcheside (Botany School, Cambridge) reviewed the normal behaviour of chromosomes at division, and the behaviour of the various types of structurally changed chromosomes, viable and lethal, which can be produced by irradiation of plant and animal cells. The yield of chromatid, chromosome and isochromatid breaks is proportional to dose and independent of intensity with all radiations. These aberrations are believed to be due to the passage of single ionizing particles through chromosomes. Exchanges between two breaks produced by X-rays increase more rapidly than the first power of the dose, and their yield diminishes with increase of exposure time, indicating that the breaks are usually produced by separate ionizing particles. In experiments with neutrons, the two breaks taking part in an exchange are usually produced by the same ionizing particle.

Dr. D. E. Lea showed how numerical data on the production of various types of aberration by the irradiation of *Tradescantia* microspores at early prophase can be made to yield valuable information: thus estimates can be made of the distance apart at the moment of their formation of breaks which exchange, of the time for which a newly formed break remains open, and of the proportion of breaks primarily formed which restitute. For an ionizing particle to have a probability approaching unity of breaking a *Tradescantia* chromatid, it must be sufficiently densely ionizing to produce about twenty ionizations in the chromatid.

Dr. P. C. Koller (Royal Cancer Hospital, London) described changes produced by irradiating tumours in human beings. Two effects, both of practical importance in radiotherapy, must be recognized: a direct effect on the tumour cells leading to chromosome fragmentation which is lethal to the cell at division, and an indirect effect due to the reaction of the tumour bed to the radiation. Fragmentation of chromosomes can be demonstrated in a few cells after 25 r., while above 300 r. a majority of the cells have several fragments. Very heavy doses produce an unnecessarily large amount of fragmentation. There appears to be scope for improvement in the methods of fractionation of dose employed in radiotherapy, designed to permit damaged cells to enter division (when they die), and also to avoid undue damage to the tumour bed which prevents the full advantage being obtained of the indirect effect.

Radiation and Germ Cells

Prof. J. B. S. Haldane said that recent advances in nuclear physics had led to the possibility that in the future larger numbers of people will risk exposure to ionizing radiations, and make it urgent to obtain some understanding of the probable frequency of genetical changes produced by the irradiation of human germ cells. It is unsatisfactory that at the moment there are no data available about mammals, apart from a little information in the case of the mouse. Nearly all mutations are deleterious. The elimination of a very deleterious mutation requires, on the average, one genetic death. A mutation reducing fitness by 10 per cent will appear in about ten individuals in the course of time before it is finally eliminated from the population.

Dr. A. Glucksmann (Strangeways Laboratory, Cambridge) described the normal processes of spermatogenesis and oogenesis in man, in rodents, and in the fruit-fly, and the effects of radiation on the gonads. In male mice, doses of a few hundred roentgens cause the disappearance after two or three weeks of all stages later than undifferentiated spermatogonia, with resulting loss of fertility. Eventual return of fertility is due to the regeneration of the seminal epithelium from these residual spermatogonia. Consequently, offspring conceived after the period of temporary sterility are derived from sperm which were irradiated as spermatogonia.

Dr. D. G. Catcheside gave reason why the rate of induction of gene mutations by radiation in man might be expected to be of the same order as in *Drosophila melanogaster*, where it approaches 0·1 per cent per roentgen. In *Drosophila* the yield is proportional to dose and independent of intensity, so that there is no tolerance dose or intensity below which one is completely safe from radiation-induced mutation. The mutation-rate for non-lethal mutation is nearly the same in sperms and spermatogonia. Dr. A. S. Parkes (National Institute for Medical Research, London) described the induction of dominant lethals by radiation, that is, the failure of a proportion of the eggs fertilized by irradiated sperm to reach the adult stage.

Dr. D. E. Lea reviewed evidence which shows that dominant lethals are due to lethal types of chromosome structural change. Viable types of chromosome structural change lead (in mice) to hereditary partial sterility. This effect is exhibited by part of the offspring of an affected animal dying before birth, and is transmitted to half the living offspring in each generation. The rate of induction is about 0·03 per cent per roentgen in mature sperm, considerably less in ova and in spermatogonia.

Summarizing, it appears that there is no reason to doubt that ionizing radiations are able to produce genetic changes in human beings whose gonads are exposed to them, and that such changes are undesirable. There is reason for believing that at low intensities the yield of all types of genetical changes is proportional to dose and independent of dose-rate, so that there is, strictly, no 'tolerance' dose or dose-rate. Any figure recommended, therefore, must be a compromise arrived at by weighing the disadvantage of the corresponding mutation-rate against the inconvenience of enforcing a higher measure of protection.

CHEMISTRY OF THE FEULGEN AND DISCHE NUCLEAL REACTIONS

By Dr. M. STACEY, R. E. DERIAZ, Dr. ETHEL G. TEECE* and Dr. L. F. WIGGINS
Chemistry Department, University of Birmingham

FOR the detection of nucleal material in cells there are available numerous staining methods[1], of which the most useful to chemists are perhaps the Feulgen[2] and the Dische[3] reactions. There is a particularly extensive literature[4] on the applications of the Feulgen reaction (which depends on the restoration of the colour to Schiff's fuchsin – sulphurous acid reagent after a preliminary gentle acid hydrolysis of the cell material), though the reaction is generally less specific in so far as any liberated aldehyde would give a positive test. On the other hand, the Dische reaction (the development of a characteristic blue colour on heating the material with diphenylamine under rigidly controlled conditions of acid concentration, time and temperature) is claimed to be sharply specific. Both the tests depend upon the presence of the sugar derivative, deoxyribose, which is invariably combined in deoxyribonucleic acid or derivatives thereof.

In view of the highly important function of deoxyribonucleic acid in the nucleal material of all types of cells[5], it appeared advisable to examine the mechanism of these reactions, the Dische reaction in particular. We have succeeded in showing that by a relatively gentle acid hydrolysis, deoxyribose is transformed into ω-hydroxy lævulinic aldehyde; and that it is this labile aldehyde which is responsible for the blue coloration with diphenylamine and which is also probably responsible for restoring the colour to Schiff's reagent in the Feulgen test. The investigations leading to this conclusion are briefly described below.

A wide range of carbohydrate derivatives and aldehydes was submitted to the precise conditions of the Dische test (cf. ref. 6), and in general the colour reactions could be classified into the following four types:

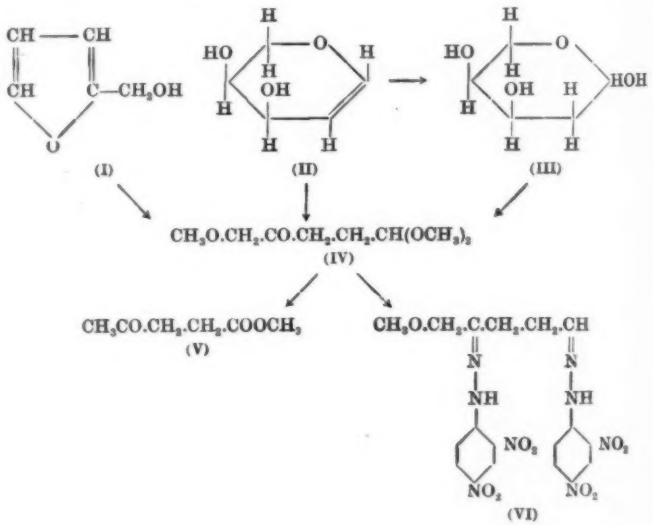
(1) Aldopentoses, aldohexoses, disaccharides such as maltose and lactose, polysaccharides such as starch and glycogen, and many esters and ethers of these substances, gave no coloration.

(2) Sucrose and fructose, ω-hydroxymethyl furfural, furfural and many other aldehydes including benzaldehyde, salicylaldehyde, etc., gave an intense green coloration.

(3) Lactal, galactal and triacetyl glucal gave a strong violet coloration.

(4) Furfuryl alcohol (I), *l*-arabinal (II), and *l*-deoxyribose (III) (written for convenience in the pyranose form) gave the characteristic vivid blue coloration shown by deoxyribonucleic acid.

Now it is known that (II) can readily be transformed into (III) by means of acid[7] and that both (I)[8] and (III)[9] yield lævulinic acid in good yield as the end product of acid hydrolysis. Since lævulinic acid gave a completely negative Dische reaction, search was made for a common intermediate in the conversion of (I), (II), and (III) into lævulinic acid. Pummerer and his colleagues[8,10] have shown that (I) can be converted by methanolic hydrogen chloride (0·1 per cent) into ω-methoxy lævulinic aldehyde dimethyl acetal (IV), which on further hydrolysis with the same reagent (2 per cent) is converted into methyl lævulinate (V). Accordingly by refluxing (I) for three hours with methanolic hydrogen chloride (0·1 per cent), (IV) was produced in the form of a colourless mobile liquid and was characterized by formation of its *bis* 2:4-dinitrophenyl hydrazone (VI), m.p. 221°. In the Dische reaction (IV) was hydrolysed and gave the characteristic blue coloration, while quantitative measurements showed that the intensity of the colour was slightly greater than that given by equivalent weights of either (I), (II), (III) or deoxyribonucleic acid.



In the Feulgen reaction, (II), (III), and (IV) gave a positive test, but colorimetric estimations of the reaction were not sufficiently consistent for comparison with deoxyribonucleic acid. Treatment of (IV) with 2 per cent methanolic hydrochloride converted it smoothly into (V) (characterized by formation of its 2:4-dinitrophenyl hydrazone, m.p. 141°) which gave a negative Dische reaction. (IV) has been prepared from both (II) and (III), though in each case it was contaminated with (V), and separation of the two, particularly in the case of the mixture derived from (III), was somewhat difficult. The main product from the refluxing of (III) with 0·1 per cent methanolic hydrogen chloride was a new methyl *l*-deoxyriboside and it was necessary to heat (III) at 180° in a sealed tube in order to obtain (IV) (10 per cent yield). Separation of (IV) and (V) was achieved by conversion of (V) by means of methanolic potassium hydroxide into its potassium salt followed by formation of (VI) from the ether-soluble residue. The complete identity of (VI) from each source was established by analysis, mixed melting point determinations and X-ray powder photographs.

* Beit Memorial Research Fellow.

It is clear that any substance capable of giving ω-hydroxy lævulinic aldehyde under the conditions of acid concentration and temperature as used in the Dische and Feulgen reactions will give a positive result. Since Pummerer and Gump[8] hold the view that (IV) is an intermediate in the conversion by acids of ω-hydroxymethyl furfural into lævulinic acid, sucrose and fructose (which readily yield ω-hydroxymethyl furfural with acids) and ω-hydroxymethyl furfural itself, were separately heated under slightly increased acid concentration with diphenylamine. A blue coloration identical with that given by (IV) was obtained. Thus our work has shown that the Dische and Feulgen reactions must be carried out under rigidly controlled conditions and with great care. Interpretation of positive results as indicating the presence of deoxyribonucleic acid must be supported by other evidence such as purine nitrogen/phosphorus ratios and spectrographic analysis. Since the natural mode of linkage of (III) with purines and pyrimidines shows important differences[3,5], we are investigating the production of (IV) from various compounds of (III) (*d*-form). Full details of this work will be published elsewhere.

We are greatly indebted to Dr. F. J. Llewellyn for the X-ray powder photographs.

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ANT GYNANDROMORPHS AND OTHER MOSAICS

By DEREK WRAGGE MORLEY
Department of Agriculture, University of Cambridge

At a meeting of the Royal Entomological Society of London on December 5, 1945, Mr. H. Donisthorpe[1] exhibited fifty gynandromorphs of *Myrmica scabrinodis sabuleti*, Mein, all taken from a single colony on the Isle of Ireland's Eye, Dublin Bay.

Wheeler[2] has described in detail a colony of *Acromyrmex octospinosus*, Reich, in which ten gynandromorphs and many other anomalous forms (including forty-one so-called 'gynergates' (female-worker mosaics)) were present. In the introduction to the same book a colony of *Cephalotes atratus quadridens*, De Geer, containing "at least 4,000 gynandromorphs", which was discovered by Weber, is mentioned. Although Weber's 4,000 'gynandromorphs' have never been described, Whiting[1] states that in fully 95 per cent the male component is confined to the head.

The ant gynandromorphs may be divided into two fairly distinct categories: (1) antero-posterior gynandromorphs; (2) lateral gynandromorphs. The former class comprises chiefly the ergatomorphic males described by Santschi[4] for *Cataglyphis*, Wheeler[5] for a fossil *Iridomyrmex*, and Lomincki[6] for *Myrmica rugulosa*. Typically these forms have the head, thorax and gaster predominantly worker or female, and the genitalia and antennæ male.

Wheeler[7] interprets these anomalous forms, together with all the ergatomorphic males of *Ponera punctatissima*, *Ponera eduardi* and other species of that genus, as "antero-lateral gynandromorphs or intersexes". I take this to mean, quite rightly in my opinion, that Wheeler did not regard these as true sex-mosaics or gynandromorphs, but as intersexes in the sense of Goldschmidt's[8] *Lymantria* ones.

The true genetic mosaic involves some form of aberrant division in the earliest stages of cell-division in the egg, and usually involves at least partial chromosome elimination. It is typified by the occurrence of scattered mosaicism in many different parts of the body. The intersex begins development as one sex; but later, owing to a change in physiological conditions, development shifts so that the organs eventually developed are according to the pattern of the opposite sex. The intersex is typified by a less scattered form of mosaicism, as in the antero-lateral gynandromorphs.

For this reason it is preferable to regard the so-called dinergatandromorphs (soldier-male mosaics) of Wheeler[9] (*Camponotus*) and Vandel[10] (*Pheidole*), together with Wheeler's[2] 'gynergates' (female-worker mosaics) as phenotypic intersexes. There can be little doubt that most, if not all, of Weber's 4,000 gynandromorphs are also intersexes.

Whiting[3] suggests that the occurrence of large numbers of these mosaic forms in single colonies is due to genetic factors and postulates a mixture of strong with weak sex factors within the colony. Thus there may be a tendency for "the diploid intercaste [to] begin development towards the worker end of the series and later deviate across the sex boundary towards the male, while the haploid caste starting as a male deviates towards or beyond the female". Donisthorpe's gynandromorphs are of special interest in that while the mosaicism is, I understand, scattered, it has been suggested that their occurrence in such numbers is due to strong local shocks caused by a vibrator situated in Dublin Bay near Ireland's Eye island.

The bearing of these mosaic forms on the problem of caste determination in ants is obvious. The male-female determination is undoubtedly genetic, and this is supported by the occurrence of what appears to be true mosaic gynandromorphs.

Huxley[11] has shown that the soldier-worker series in some of the harvesting ants form a typical acromegalic growth-curve. The experimental work of Goetsch[12] and Gregg[13] on this problem is, however, inconclusive. The same applies in the case of worker-female determination: Ezhikov[14] subjected *Camponotus* and *Myrmica* larvæ to hunger, but failed to obtain forms transitional between the worker and female, although he obtained females reduced in size. Wesson's[15] work is interesting but statistically inconclusive. More recently, Flanders[16] has put forward the hypothesis that the worker-female determination depends on the amount of nutrient in the egg, and thus on the rate of oviposition. There is, however, no myrmecological experimental evidence to support this theory. Much of the large body of experimental work on this subject has been ably summarized and discussed by Light[17].

Tulloch[16] has described a *Myrmecia* lateral 'gynergate'. In this specimen one side possesses for the most part typically female characteristics and the

other typically worker ones. On the female side of the thorax a vestigial hind wing is still present, with the place of insertion of the fore-wing clearly marked. The parascutal ridge and transental suture together with other female characters are present. The node is asymmetrical.

Is this a true sex-mosaic ? It is difficult to say, but it is the only ant 'gynergate' so far described to have the appearance of a genuine mosaic. It is not, by itself, sufficient evidence for the rejection of the trophogenic hypothesis for female-worker determination, which would appear more probable in the light of the trophogenic mechanism known to exist in the closely allied bees.

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NATIONAL CENTRAL LIBRARY

THE twenty-eighth and twenty-ninth annual reports of the executive committee of the National Central Library, London, W.1, published as one report, cover the two years ended February 28, 1945. The most notable event in the history of the library in 1944 was the retirement for reasons of ill-health of Dr. Luxmoore Newcombe, its first librarian, to whose work a warm tribute is paid. Mr. R. H. Hill was appointed librarian and secretary to the Trustees as from January 1, 1945. Another serious loss to the staff was due to the appointment of Mr. J. H. P. Pafford, sub-librarian, as Goldsmith's librarian of the University of London. The work of the Library continued to be carried out, though with increasing difficulty, in the intact portion of the Malet Place premises and in the temporary quarters at Bourne End. Damage due to enemy action in April 1941 reduced the number of books in the Library from 176,961 to 72,612, a figure which had been increased to 88,760 by the end of February 1945. Total issues of books during the two years were 55,539, and 57,672, respectively, of which 3,553 and 4,580 were to university libraries, 4,414 and 4,398 to special outlier libraries and 6,354 and 6,568 to the libraries of Government Departments, research and industrial organisations, etc., the corresponding figures for 1938–39 being 58,683, 3,538, 5,289 and 2,588, respectively. The group of outlier libraries now includes 137 special libraries, 2 urban libraries and 23 London borough libraries, libraries added during the two years including the Austin Motor Co., Ltd., Birmingham, Cement and Concrete Association, Evans Biological Institute, Royal Veterinary College and the Textile Institute. Eighteen university libraries and fifty-two special libraries are now co-operating in the regional systems, but no figures are available for the issue of books to university libraries, although 5,889 books were lent by them to other libraries in 1943–44 and 7,151 in 1944–45. An increase of 132,408 entries in the union catalogues is now reported, the grand total now standing at 4,373,798, of which a hundred thousand at the National Central Library relate to university periodicals.

After consideration of suggestions made by the Library Association as an outcome of the McColvin Report, the trustees have indicated their agreement with three recommendations concerning the National Central Library made to the Council of the Association. These relate to the provision of a department of the central government charged with the duty of guiding, co-ordinating and encouraging the development of local library services, of making grants-in-aid, and of promoting the establishment and maintenance of those departments of the service which can most efficiently be provided for areas larger than those of library authorities—among which would fall inter-library co-operation and the work of the National Central Library. Secondly, better local provision should be made by larger authorities with more comprehensive book-stocks, thus strengthening and developing the National Central Library so as to provide for the interchange of the more specialized older and less readily obtainable material. The third proposal relates to the establishment as part of, or in close association with, the National Central Library, of a central cataloguing department; and the trustees have already adopted a memorandum on the establishment of such a department. The executive committee has also approved the appointment of a committee to consider the compilation of a complete union catalogue of periodicals in British libraries of all types, and work on this project has now begun.

RHEOLOGY IN THE FOOD INDUSTRY

RHEOLOGY in the food industry was the subject of discussion at a joint meeting of the British Rheologists' Club and the Royal Institute of Chemistry of Great Britain and Ireland (London and S.E. Counties Section) held on April 2 at the Royal Society of Arts, London, Dr. G. L. Riddell being in the chair.

Dr. E. C. Bate-Smith, of the Low Temperature Research Station, Cambridge, indicated opportunities for the use of rheological methods and principles in the examination of meat during the period between slaughtering and butchering when 'setting' or rigor mortis occurs. The changes due to coagulation of muscle proteins can be followed by measurements of the elastic modulus of the muscle fibre (single fibres obey Hooke's law but connective tissue shows elastic return creep) and the rate of change indicates the quality of the meat, deficiency in glycogen, etc. Various methods and standard machines were described for measuring the toughness of meat. In the discussion, Dr. J. G. A. Griffiths inquired about the large scatter of results for toughness obtained by machines in which the meat specimen is sheared or punched by a moving 'tooth' and the peak load measured, and Mr. W. Baker suggested that the differences between results obtained by the machine

and by judgment of a panel may be as much due to the meat samples being differently cut, along or across the grain, as to the lack of repeatability of the machine.

Mr. R. Barry Drew, of British Glues and Chemicals, Ltd., spoke on the examination of various grades of gelatine prepared by extraction of collagens. The relationship between average chain-length and rheological properties of the proteins has not yet been worked out. In the trade, the Bloom gelometer, by which the depression of a loaded cylinder resting on a jelly is recorded, is employed for appraising gelatines, the depression being proportional to the weight and inversely proportional to the radius of the cylinder. Formulæ relating depression and size of pot (rise of jelly-level), the depression and concentration, etc., were given. Mr. Drew exhibited research apparatus for measuring by torsion the modulus of rigidity of jellies. In reply to questions by Dr. L. R. G. Treloar whether the elasticity of gelatine gels has been measured by simple shear, Mr. Drew said that torsion methods are popular mainly because of the convenience in dealing with very thin gels. The square-law relation between rigidity and concentration appears to be general for a large number of gelatines.

Mr. J. E. Caffyn, of the National Institute for Research in Dairying, Reading, in introducing the subject of rheology in dairy research, emphasized the important place the new science takes, especially in following the changes in butter- and cheese-making. For the convenience of users, it is important in butter-making to strike a balance between too soft a consistency under summer conditions and difficulty of spreading at winter temperatures. Viscosity results with milks, which behave almost as Newtonian liquids, are instructive, although there is a scatter of results due to partial separation during the tests. Condensed milks tend to form a structure on standing, and Mr. Caffyn demonstrated an interesting example of rheodestruction. He exhibited research apparatus for measuring the consistency of cheese in the various stages of its manufacture. Mr. P. T. Clarke, of Kraft Cheese Co., Ltd., in reference to Dr. Bate Smith's and Mr. Caffyn's papers, asked whether psycho-chemical methods should not be used to determine what test panels or grades measure subjectively before any attempt is made to design instruments to give objective readings. Mr. H. B. Oakley, of the Research Dept., Lever Bros., inquired as to whether 'springiness' of butter is important in grading as 'fight back' is with cheese.

Dr. E. W. J. Mardles mentioned that the committee of the British Rheologists Club is discussing the possibilities of finding a more suitable word than 'rheodestruction' for denoting the irreversible decrease in consistency with shear.

PLANT VIRUSES

THE Cantor Lectures delivered by Dr. F. C. Bawden to the Royal Society of Arts (*J. Roy. Soc. Arts*, **94**, No. 4710, Feb. 1946) provide a welcome review of modern developments in the investigation of plant virus diseases. Such maladies can now only be defined as infectious diseases with invisible causes; their filter-passing character is not common enough for incorporation in a definition. Even the term 'invisible' is yielding to investigations by the electron microscope, and Dr. Bawden includes an electron micrograph of tobacco mosaic virus as one of his twenty-one half-tone illustrations. Viruses are, however, still invisible in ordinary light. The text suggests that on the purely practical side, it might be good to reduce losses from virus infection by breeding hypersensitive varieties of host crops, which would eliminate the diseases automatically. It might also be profitable to investigate the possibilities of conferring acquired immunity upon a clone by inoculating it with a mild, harmless virus which would preclude the entry of a more virulent pathogen. This, however, is inspiration for the future rather than technique for the present.

Many viruses cause an accumulation of starch in the leaves, as was originally described for leaf-roll of potatoes. Top-necrosis of the potato induces necrosis of the phloem and other tissues, whereas leaf-drop streak kills the cortical tissues of the stem, and does not affect the vascular tissues. The disease known as rubbery wood of Lord Lambourne apples prevents the wood from becoming fully lignified. An interesting development in the investigation of internal symptoms is the simulation of inclusion bodies *in vitro* by precipitating purified viruses with various substances with which they combine to form insoluble complexes.

The use of dodder (*Cuscuta* sp.) as an agent for transmission promises to become a valuable item of research technique. Many viruses can only be transmitted by biological methods, that is, by grafting and by insect vectors. Grafting imposes a limit upon possible host-range, but dodder may extend the parasitism of biologically transferred viruses to hosts which have not hitherto been grafted. Mechanically infective viruses can infect at much greater dilutions if an abrasive such as 500-mesh carborundum is incorporated in the inoculum. More information is also to hand about the intimate relations between a virus and its insect vector. Short feeding periods of vectors are often more efficient than prolonged ingestion. At least one virus—dwarf disease of rice—is transmitted by the egg of its leaf-hopper vector.

A great deal of investigation into the ecology of virus-spreading insects is necessary; but already it appears that species vary in their mobility within a crop, and therefore in their ability to disperse viruses in the field. The peach aphid, *Myzus persicæ*, appears to move about within a crop; it is an efficient vector of viruses in the field. *Aphis fabæ* transmits mosaic and yellows of sugar beet as well as does *M. persicæ* in greenhouse tests, but appears to confine its attentions to relatively few plants in the field, where it is but a poor vector of these diseases.

Dr. Bawden's text reviews much work upon the purification and chemical properties of viruses, giving elementary analyses of several purified virus preparations, and mentioning the proportions of various amino-acids in tobacco mosaic virus. Two essential constituents, nucleic acid and protein, seem to account for almost the whole chemistry of viruses. Work with electron microscopes seems to reinforce earlier estimates of the general size and nature of virus particles. It is considered "probable that the multiplication of viruses is a process more akin to that whereby the individual constituents of normal cells are produced than to the actual multiplication of whole cells". The general student of virus diseases should read this paper in order to be up to date in his subject by easy stages; he will find much more detailed discussion than can be noted in this present review.

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, June 3

FARMERS' CLUB (at the Royal Empire Society, Craven Street, Strand, London, W.C.2), at 2.30 p.m.—Mr. H. W. Steele-Bodger: "A National Policy for the Control of Animal Diseases".

Tuesday, June 4

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Dr. G. M. Morant: "Anthropometric Enquiries in the Royal Air Force".

ROYAL PHOTOGRAPHIC SOCIETY, SCIENTIFIC AND TECHNICAL GROUP (at 21 Prince's Gate, London, S.W.7), at 6 p.m.—Dr. W. Swift: "How it Works in Photography", 5: "Viewing the Print and the Subject".

Wednesday, June 5

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (joint meeting with the ROYAL SANITARY INSTITUTE, in the Indian Lounge, Winter Garden, Blackpool), at 10 a.m.—Discussion on "The Nutritive Value of Processed Foods". Prof. S. J. Cowell: Introductory Address; Mr. W. B. Adam: "The Nutritive Value of Vegetable Products"; Dr. Ethel M. Cruickshank and Dr. E. Kodicek: "The Nutritive Value of Animal Products". (This meeting will constitute the Food and Nutrition Section of the Health Congress (June 3–7) arranged by the Royal Sanitary Institute.)

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Engineer Rear-Admiral S. R. Dight: "The Production and Use of Artificial Fog for Protection Purposes during the War".

INSTITUTE OF WELDING (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 2.30 p.m.—Annual General Meeting; at 3 p.m.—Discussion by Mr. J. L. Adam and Mr. C. S. Lillicrap on "Future Ships—Will they be All-Welded ?"

ROYAL SOCIETY OF MEDICINE, HISTORY SECTION (at 1 Wimpole Street, London, W.1), at 2.30 p.m.—Dr. Douglas McKie: "Joseph Black, M.D. (1728–99)".

ROYAL STATISTICAL SOCIETY, RESEARCH SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Dr. H. O. Hartley: "The Application of some Commercial Calculating Machines to certain Statistical Calculations".

ROYAL ENTOMOLOGICAL SOCIETY OF LONDON (at 41 Queen's Gate, London, S.W.7), at 5.30 p.m.—Dr. W. H. Thorpe: "Plastron Respiration, a Chapter in the Natural History of Aquatic Insects".

INSTITUTION OF ELECTRICAL ENGINEERS (at the Central Hall, Westminster, London, S.W.1), at 6 p.m.—Dr. T. E. Allibone: "Atoms, Electrons and Engineers" (Faraday Lecture).*

Thursday, June 6

CHEMICAL SOCIETY (joint meeting with the UNIVERSITY OF OXFORD ALEMBIC CLUB, at the Physical Chemistry Laboratory, South Parks Road, Oxford), at 2 p.m.—Discussion on "The Chemistry of Antibacterial Substances".

Friday, June 7

GEOLOGISTS' ASSOCIATION (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Dr. Gilbert Wilson: "The Relationship of Slaty Cleavage and Kindred Structures to Tectonics".

Tuesday, June 4—Friday, June 7

INSTITUTION OF GAS ENGINEERS (at the Institution of Civil Engineers, Great George Street, London, S.W.1)—Eighty-third Annual General Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

HEAD OF THE CHEMISTRY DEPARTMENT—The Director of Education, College of Technology, Belfast (June 11).

LECTURER IN PSYCHOLOGY—The Registrar, The University, Reading (June 11).

DEMONSTRATOR (man or woman) IN THE DEPARTMENT OF GEOLOGY—The Secretary, Bedford College for Women, Regent's Park, London, N.W.1 (June 15).

DEMONSTRATOR IN PHYSIOLOGICAL CHEMISTRY—The Registrar, The University, Manchester (June 15).

LECTURERS (2) IN THE CHEMISTRY DEPARTMENT—The Secretary, The University, St. Andrews (June 15).

LECTURERS IN (*a*) MECHANICAL ENGINEERING, (*b*) ELECTRICAL ENGINEERING, (*c*) PHYSICS and (*d*) PHYSICAL CHEMISTRY—The Clerk to the Governors, South-West Essex Technical College and School of Art, Forest Road, Walthamstow, London, E.17 (June 15).

MASTER to teach ENGINEERING—The Clerk to the Governors, Mid-Essex County Technical School, Market Road, Chelmsford (June 15).

LECTURERS (men and women) IN PHYSICS, IN CHEMISTRY (one with bias toward Organic Chemistry, one toward Physical Chemistry), IN MATHEMATICS (to general degree standard but one with bias toward Pure Mathematics, one toward Applied Mathematics), IN BOTANY, IN ZOOLOGY, and IN GEOGRAPHY, at the Gordon Memorial College, Khartoum—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Lecturer (quoting subject), Gordon Memorial College' (June 17).

MECHANICAL ENGINEERS AND TECHNICIANS (Ref. C.218.A), PHYSICISTS (Ref. A.133.A), and a MATHEMATICIAN (Ref. A.134.A), by the Linen Industry Research Association for research and development work on flax spinning—The Ministry of Labour and National Service, Technical and Scientific Register, Room 572, York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (June 18).

LECTURERS (2) IN MATHEMATICS with qualifications in Applied Mathematics or Mathematical Physics, and an ASSISTANT LECTURER IN MATHEMATICS with qualifications in Pure Mathematics—The Registrar, The University, Manchester 13 (June 24).

ASSISTANT LECTURER IN INORGANIC AND PHYSICAL CHEMISTRY—The Registrar, Queen Mary College, Mile End Road, London, E.1 (June 29).

OFFICERS IN CHARGE of the Laboratories for Physical Chemistry and Chemical Microbiology of the South African Council for Scientific Research—The Scientific Liaison Officer, South Africa House, Trafalgar Square, London, W.C.2 (June 30).

FUEL TECHNOLOGIST to undertake the investigation of problems associated with the use of turf (peat) in domestic and industrial consumer appliances—The Secretary, Turf Development Board, 21 Fitzwilliam Square, Dublin (July 1).

LECTURER IN FORESTRY, and an ASSISTANT IN THE DEPARTMENT OF FORESTRY—The Secretary, The University, Aberdeen (July 1).

SENIOR BIO-CHEMIST (non-medical) at the Teaching and Research Laboratory in the Maudsley Hospital Post-Graduate Medical School, Denmark Hill, London, S.E.5—The Medical Officer of Health (I), Mental Health Services, County Hall, London, S.E.1 (July 11).

TEXTILE RESEARCH OFFICER, and a TEXTILE RESEARCH CHEMIST, for the New Zealand Woollen Mills' Research Association, Dunedin—The Scientific Liaison Officer, New Zealand House, Strand, London, W.C.2 (New Zealand, July 15).

DIRECTOR OF THE TRANSVAAL MUSEUM, Pretoria—The Secretary, Office of the High Commissioner for the Union of South Africa, South Africa House, Trafalgar Square, London, W.C.2 (July 28).

READERSHIP IN PHARMACY—The Registrar, The University, Sydney, N.S.W., Australia (August 1).

LECTURER IN CHEMISTRY to teach Chemistry to Intermediate Science standard and Inorganic or Organic Chemistry to Degree standard, and a LECTURER IN PHYSICS AND MATHEMATICS to teach Physics and Mathematics up to Intermediate standard and Physics up to General Degree standard—The Clerk, Northern Polytechnic, Holloway, London, N.7.

LECTURER IN PHARMACEUTICAL CHEMISTRY, and a DEMONSTRATOR IN THE DEPARTMENT OF CHEMISTRY AND BIOLOGY—The Registrar, Municipal College, Portsmouth.

PROFESSORSHIP OF EUROPEAN ARCHÆOLOGY—The Registrar, University Registry, Oxford.

BASHFORTH CHAIR OF MATHEMATICAL PHYSICS at the Military College of Science—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1.

CURATOR of the National Collection of Type Cultures of Micro-organisms—The Establishment Officer, Medical Research Council, 38 Old Queen Street, London, S.W.1.

GEOLOGIST by the Government of Iraq—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.N.13778.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Other Countries

U.S. Department of the Interior: Geological Survey. Water-Supply Paper 946: Water Levels and Artesian Pressure in Observation Wells in 1942. Part 3: North-Central States. By O. E. Meinzer, L. K. Wenzel and others. Pp. iv+278. n.p. Water-Supply Paper 948: Water Levels and Artesian Pressure in Observation Wells in the United States in 1942. Part 5: Northwestern States. By O. E. Meinzer, L. K. Wenzel and others. Pp. iv+194. n.p. Water-Supply Paper 950: Quality of Surface Waters of the United States, 1942. By W. D. Collins and S. K. Love. Pp. iv+68. 15 cents. Water-Supply Paper 952: Surface Water Supply of the United States, 1942. Part 2: South Atlantic Slope and Eastern Gulf of Mexico Basins. Pp. viii+477+1 plate. 60 cents. Water-Supply Paper 953: Surface Water Supply of the United States, 1942. Part 3: Ohio River Basin. Pp. x+682+1 plate. n.p. Water-Supply Paper 954: Surface Water Supply of the United States, 1942. Part 4: St. Lawrence River Basin. Pp. v+202+1 plate. 30 cents. Water-Supply Paper 955: Surface Water Supply of the United States, 1942. Part 5: Hudson Bay and Upper Mississippi River Basins. Pp. ix+402+1 plate. n.p. Water-Supply Paper 956: Surface Water Supply of the United States, 1942. Part 6: Missouri River Basin. Pp. viii+482+1 plate. n.p. (Washington, D.C.: Government Printing Office, 1943-1945.) [1910

Catalogues

Proportioning Head for Toluene Regulator. (Technical Publication EA. 11a.) Pp. 4. (London: Sunvic Controls, Ltd., 1946.)

Londex High-Speed Contractor. (List No. 105.) Pp. 2. Londex Photo-Electric Equipment. (List No. 108.) Pp. 2. (London: Londex, Ltd., 1946.)

Kipp Galvanometers. Pp. 8. (Delft: P. J. Kipp and Zonen, 1946.)

Adjustable Thermostats. (Publication AT.10e.) Pp. 4. (London: Sunvic Controls, Ltd., 1946.)

High Vacuum for Industry. Pp. 24. (Boston, Mass.: National Research Corporation, 1946.)

From Alchemy to Chemistry and Psychology. (Catalogue 8.) Pp. 34. (London: E. Weil, 28 Litchfield Way, N.W.11, 1946.)

Books for Libraries, Scholars and Booklovers: Literature, History, Art, Law, Science. (Catalogue No. 7.) Pp. 132. (New York: Herbert Reichner, 34 East 62nd Street, 1946.)

Books, Old and Modern, mainly from Recent Secondhand Purchases, including Art, Architecture, First Editions, Military, Mountaineering, Music, Theatre, Topography, Travel, etc. (Catalogue No. 499.) Pp. 38. (Cambridge: Bowes and Bowes, 1946.)